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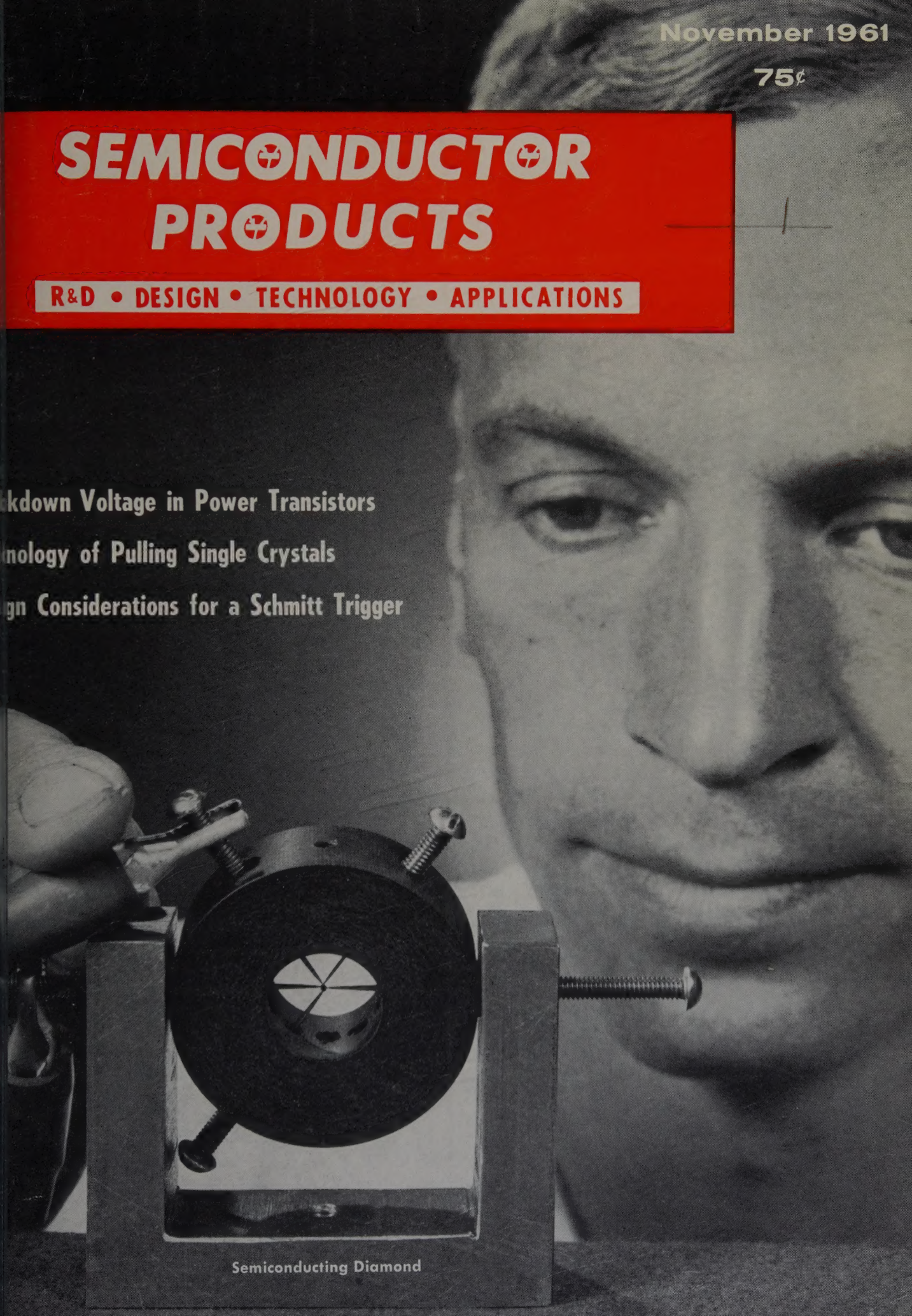

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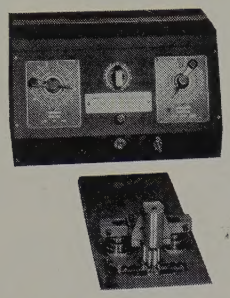

Single-head Ohmic contact sealer including controls, easily installed in dry box.

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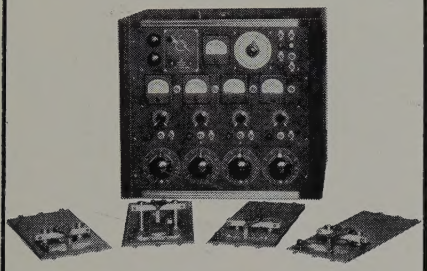

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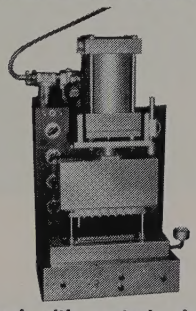

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SEMICONDUCTOR PRODUCTS

SANFORD R. COWAN, Publisher

November 1961 Vol. 4 No. 11

CONTENTS

Editorial 19

Breakdown Voltage In Power Transistors, *by Ralph Greenburg* 21
The Technology of Pulling Single Crystals (Part I), *by Henry T. Minden* 25
An Analysis of The D-C Design Considerations of a Transistorized Schmitt Trigger (Part I), *by Jack Corsiglia* 29
Applications Engineering Digests 32
Patent Review 34
Semiconductor and Solid State Bibliography 36

Departments

Current Books 8
Industry News 16
Market News 40
New Products 44
Personnel Notes 51
New Literature 52

Advertisers' Index 54

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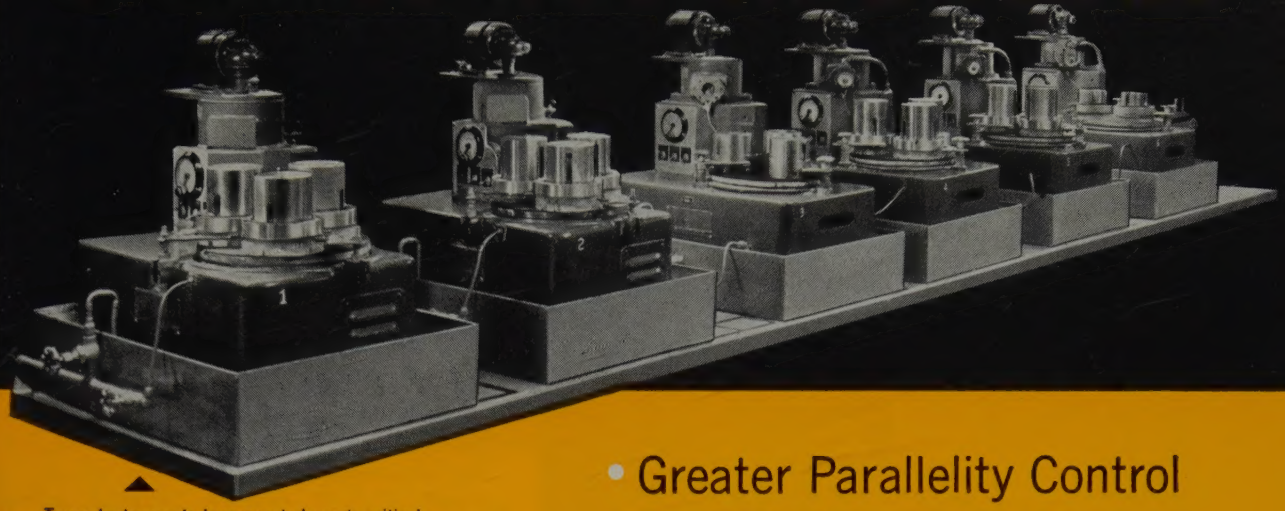
Front Cover

Dr. Robert H. Wentorf of the General Electric Research Laboratory holds a piece of semiconducting diamond in a device designed to test its electrical characteristics. Diamonds are made semiconducting by adding impurities such as boron, beryllium or aluminum to the mixture of graphite and catalyst from which the diamonds are made. The mixture is subjected to pressures of about 1 million pounds per square inch and temperatures above 2000° F. Under these conditions, diamonds form with concentrations of one per cent or less of the desired impurity, and have electrical conductivities in the semiconducting range (intermediate between those of metals and insulators).

What's new in LAPPING and POLISHING of SEMICONDUCTOR CRYSTALS



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Over 100 semiconductor manufacturers now operate batteries of these machines —around the clock in many cases. Lapmasters are relied upon to consistently produce silicon or germanium wafers to size as thin as one mil and with parallelity tolerances to .000050″.

Our wide experience in this and other fields can help you find the answers to your wafer lapping problems. Lapmaster Division engineers will work with you in developing the lapping and polishing technique that's exactly right for your particular specifications.

A few of the many new and improved techniques that work for others are shown here—contact us for more information. Request Bulletin L-450 for general information.

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SILICON NEWS from Dow Corning

Need 1-0-0 Silicon?

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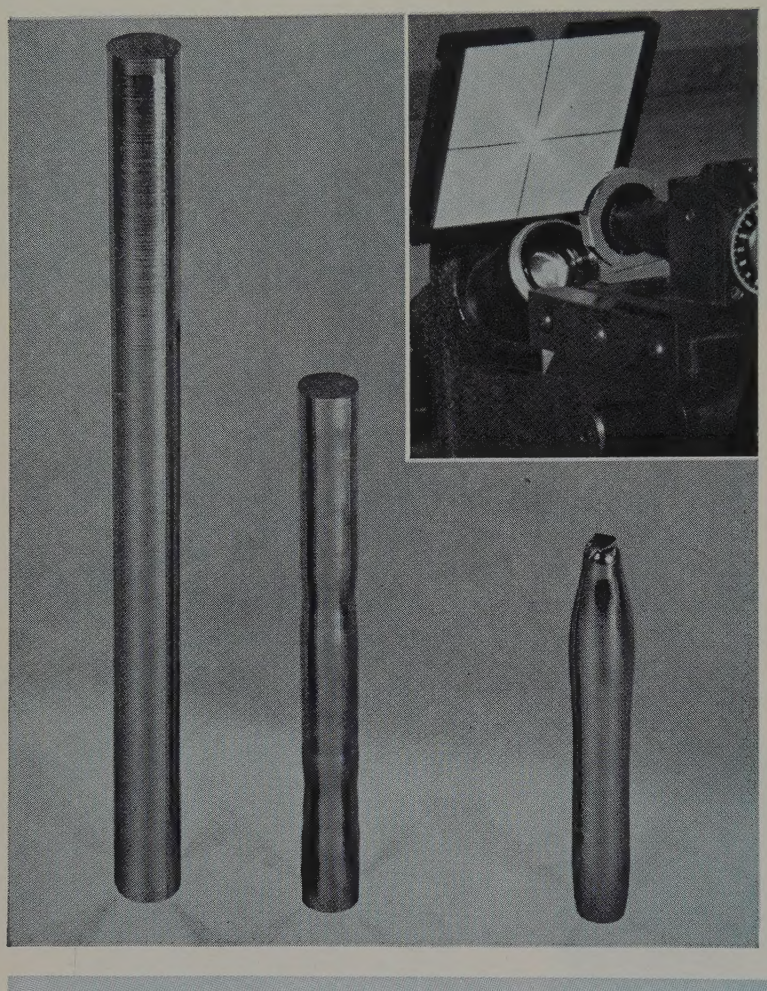

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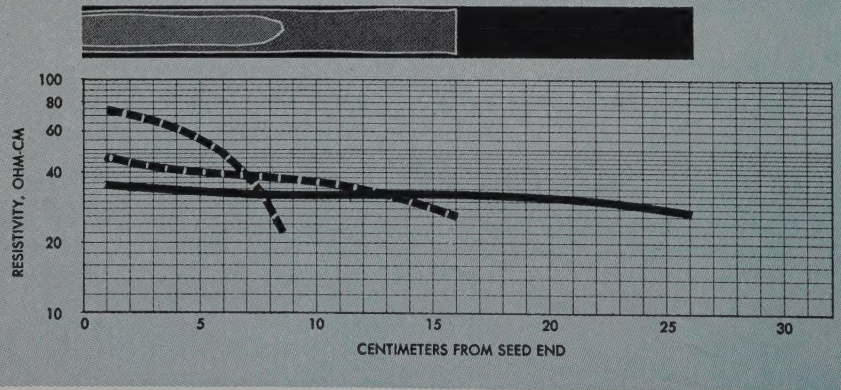

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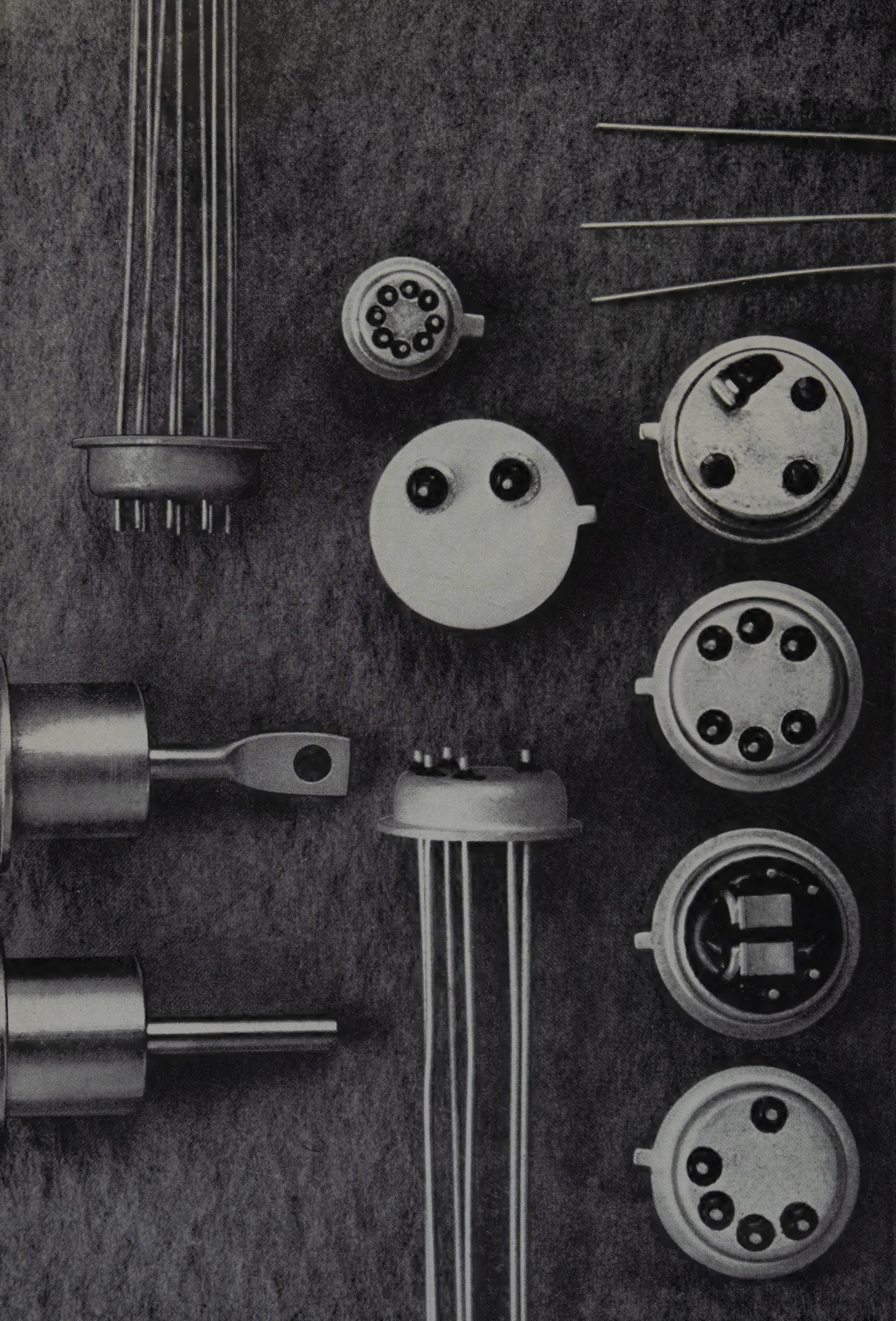

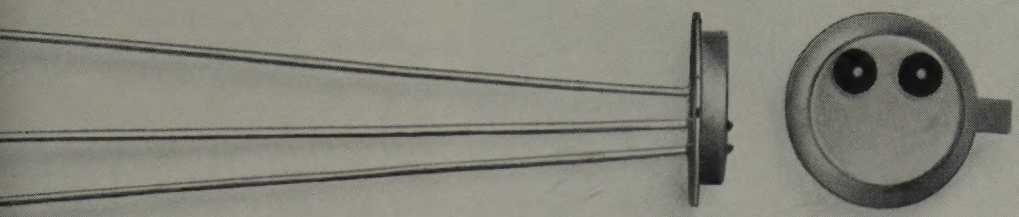

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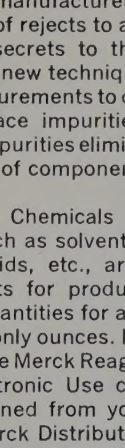

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Design Fundamentals of Analog Computer Components by R. M. Howe. D. Van Nostrand Company, Inc., Princeton, N.J. $7.50. Describes the design procedure and philosophy in the development of electronic analog computer components.

Computer Logic by Ivan Flores. Prentice-Hall, Inc., Englewood Cliffs, N.J. $12.00. How computers are put together—how they work—how to use them.

Junction Transistors in Pulse Circuits by P. A. Neeteson. The Macmillan Company, New York, N.Y. $6.95. This book gives methods which may be used to analyze the fundamental pulse circuits containing transistors and hence to simplify their design.

Electron Optics in Television by I. I. Tsukkerman. Pergamon Press, New York, N.Y. $8.50. A translation from the Russian by Louis Anderson Fenn.

Coupled Mode and Parametric Electronics by William H. Louisell. John Wiley & Sons, Inc., New York, N.Y. $11.50. Applies the coupled mode approach to space charge waves, parametric amplifiers, and related devices.

Digital Applications of Magnetic Devices; Senior Editor, Albert J. Meyerhoff. John Wiley & Sons, Inc., New York, N.Y. $14.00. Theory, electrical design, and logical design of the most representative forms of digital magnetic circuits from a single, integrated approach.

International Dictionary of Applied Mathematics. D. Van Nostrand Company, Inc., Princeton, N.J. $25.00. The broad range of coverage, the wide scope given to each area and the number of contributions included among the more than 8,000 entries in this volume bring to those of many disciplines—from physicist to chemist, from aeronautical engineer to metallurgist—an invaluable reference.

Direct Conversion of Heat to Electricity edited by Joseph Kaye and John A. Walsh. John Wiley & Sons, Inc., New York, N.Y. $8.75. This volume is an edited collection of fundamental papers covering thermoelectric, thermionic, and magnetic hydrodynamic energy conversions and fuel cells.

The Theory of Brillouin Zones and Electronic States in Crystals by H. Jones. Interscience Publishers, Inc., New York, N.Y. $9.50. This book is written for students of theoretical solid state physics, and for experimental physicists who have an interest in the study of electronic state in crystals.

Imperfections in Crystals by H. G. van Bueren. Interscience Publishers, Inc., New York, N.Y. $16.75. The subject of crystal imperfections is approached from the side of the solid state physicist, who is interested primarily in the effect which these imperfections have on the physical properties of the metallic, semiconducting or insulating materials he is investigating.

Industrial Transistor & Semiconductor Handbook by Robert B. Tomer. Howard W. Sams & Co., Inc., Indianapolis, Ind. $4.95. The latest, most up-to-date information on all types of industrial semiconductors, their operating characteristics, circuit-design procedures and typical applications.

Linear Vacuum-Tube and Transistor Circuits by Alfred J. Cote, Jr. and J. Barry Oakes. McGraw-Hill Book Company, Inc., New York, N.Y. $10.75. This text presents a basic approach to the analysis and synthesis of vacuum-tube and transistor linear circuits, emphasizing the differences and similarities between the two devices.

Electric Machinery by A. E. Fitzgerald and Charles Kingsley, Jr. Second edition. McGraw-Hill Book Company, Inc., N.Y.C. $10.75. The dynamics and statics of electromechanical energy conversion.

Basic Mathematics for Electronics by Nelson M. Cooke. Second edition. McGraw-Hill Book Company, Inc., New York, N.Y. $10.75. The book provides a full course in basic mathematics, with applications to basic electric and electronic circuits.

Metallurgy of Elemental and Compound Semiconductors edited by Ralph O. Grubel. Interscience Publishers, New York, N.Y. $13.00. Vol. 12 of the Proceedings of a Technical Conference sponsored by the Semiconductors Committee of the Metallurgy Society.

Static Relays for Electronic Circuits edited by Richard F. Blake. Engineering Publishers, Elizabeth, N.J. $7.00. Based on the Static Relays Symposium sponsored by the U.S. Army Signal Research and Development Laboratory, this book tells how to take advantage of the unusual properties of static relays.

Tunnel Diode Manual edited by the Semiconductor Products Dept., General Electric Company, Liverpool, N.Y. $1.00. This book covers tunnel diode operation, test circuits, and applications.

Transistor Substitution Handbook by The Howard W. Sams Engineering Staff. Howard W. Sams & Co., Inc., Indianapolis, Ind. $1.50. Covers over 6500 direct substitutions for transistors (including Japanese types) and diodes. Basing diagrams, polarity identifications, and manufacturers are also given.

Electronic, Radio and Microwave Physics by D. E. Clark and H. J. Mead. The Macmillan Company, New York, N.Y. $25.00. This is a reference work for experienced technicians and for teachers in the fields of physics and electronic engineering, and a primary textbook for students in those fields.

Electronic Measuring Instruments by Harold E. Soisson. McGraw-Hill Book Company, Inc., New York, N.Y. $7.50. This text provides an introduction to electronic measurement and control as used in the laboratory and industry, and offers a general background for advanced work.

Transistors—Principles, Design, and Applications by Wolfgang W. Gartner. D. Van Nostrand Company, Inc., Princeton, N.J. $12.50. This volume fully describes transistor circuit design theory and current applications.

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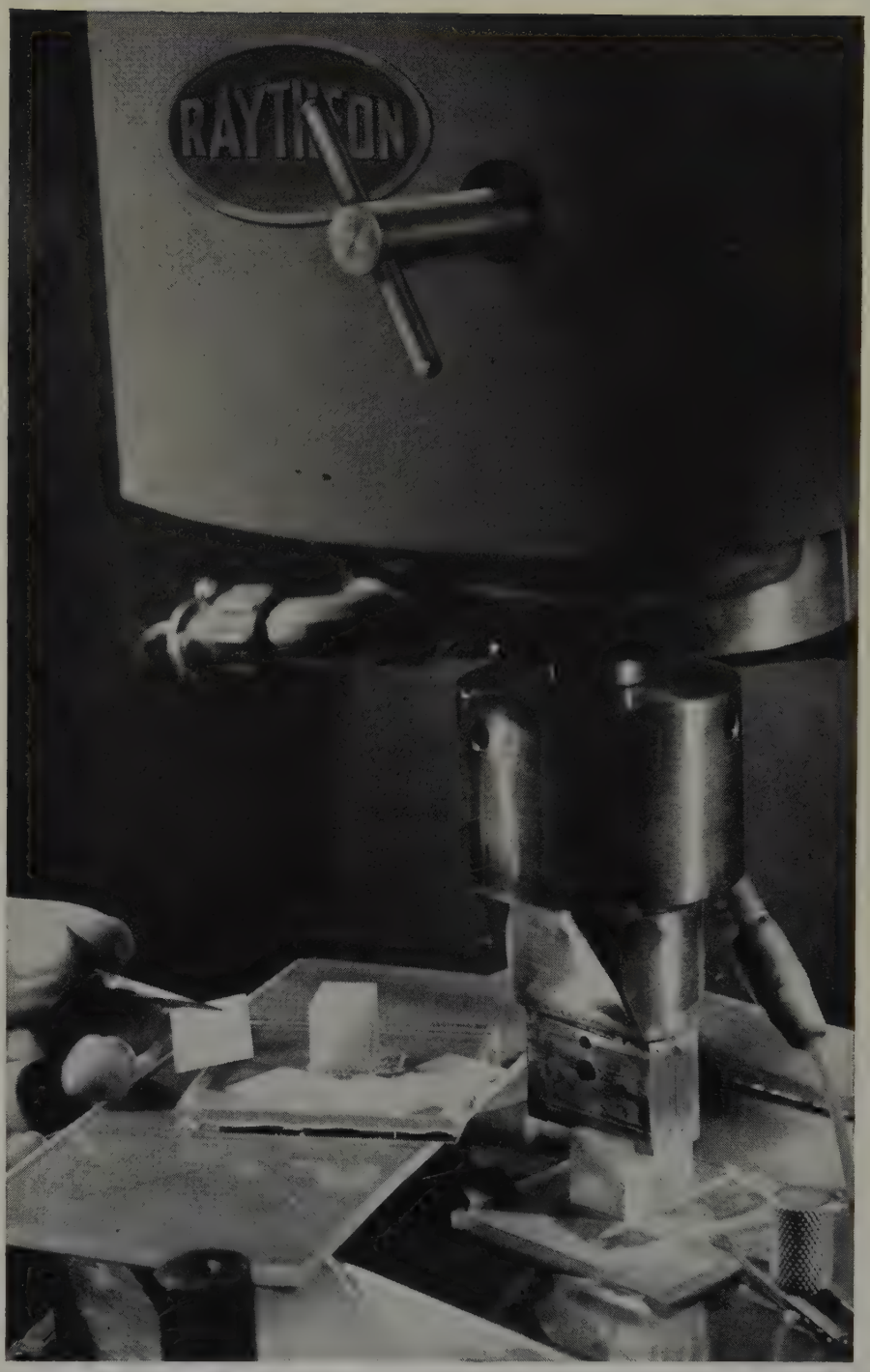

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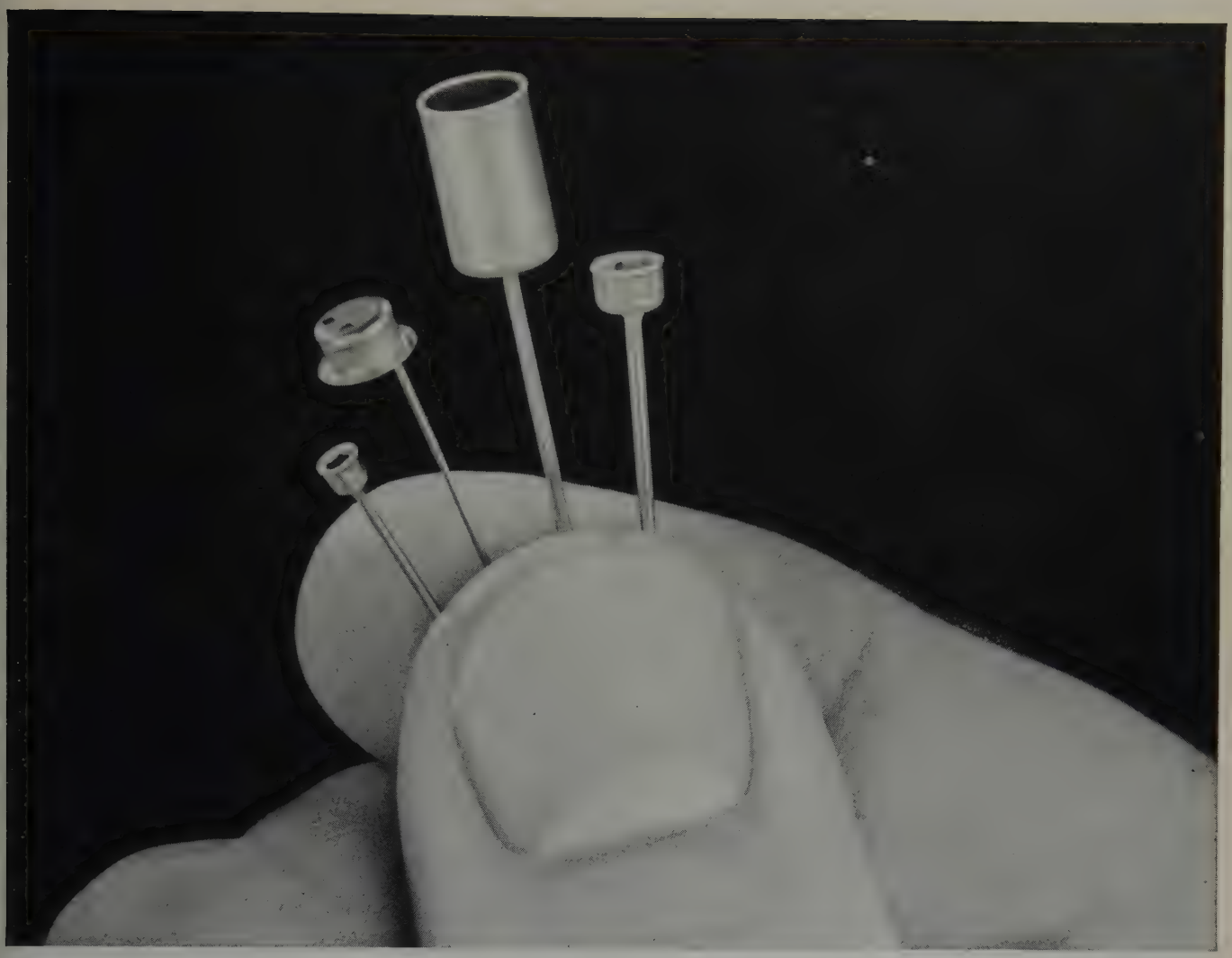

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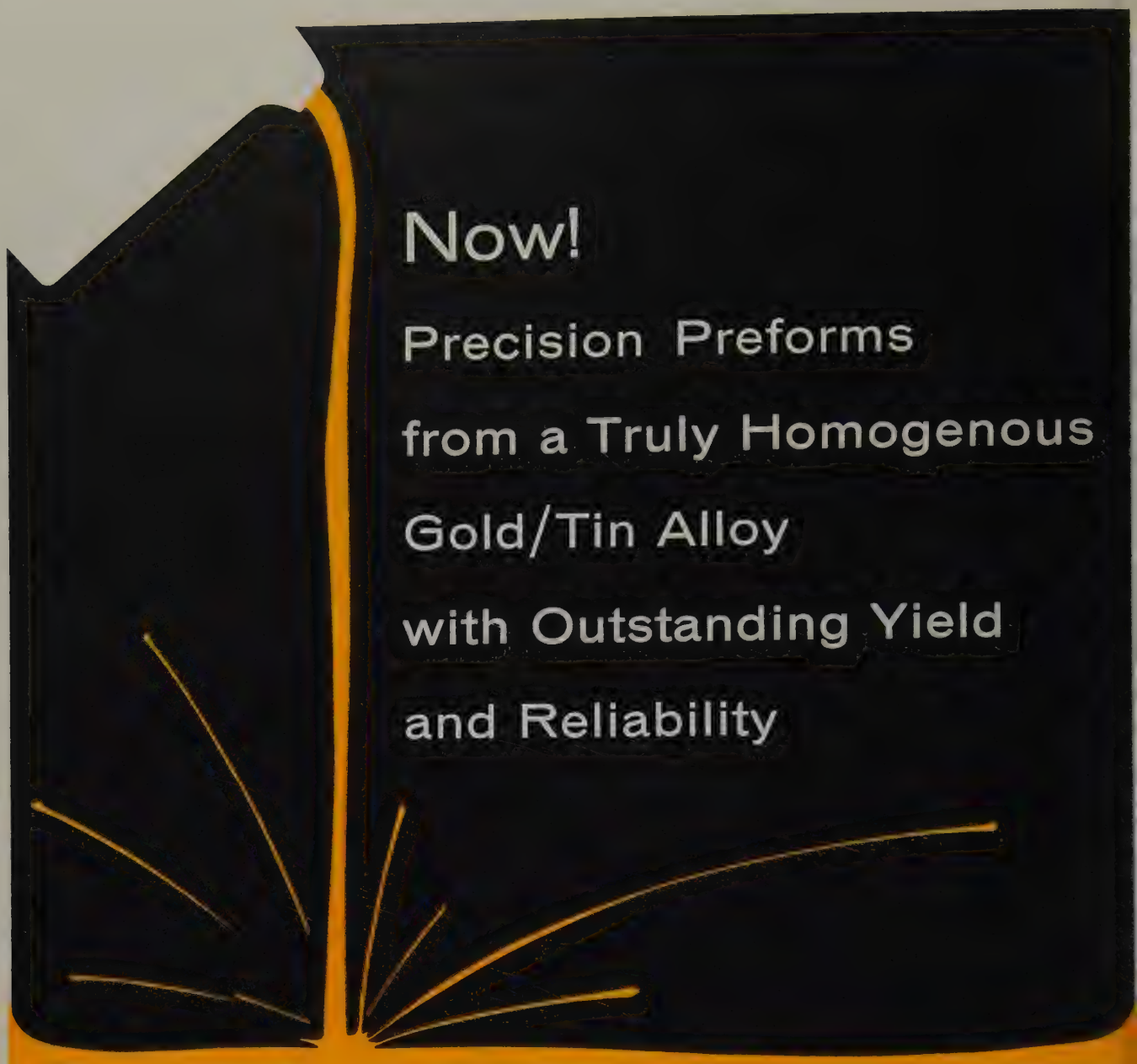

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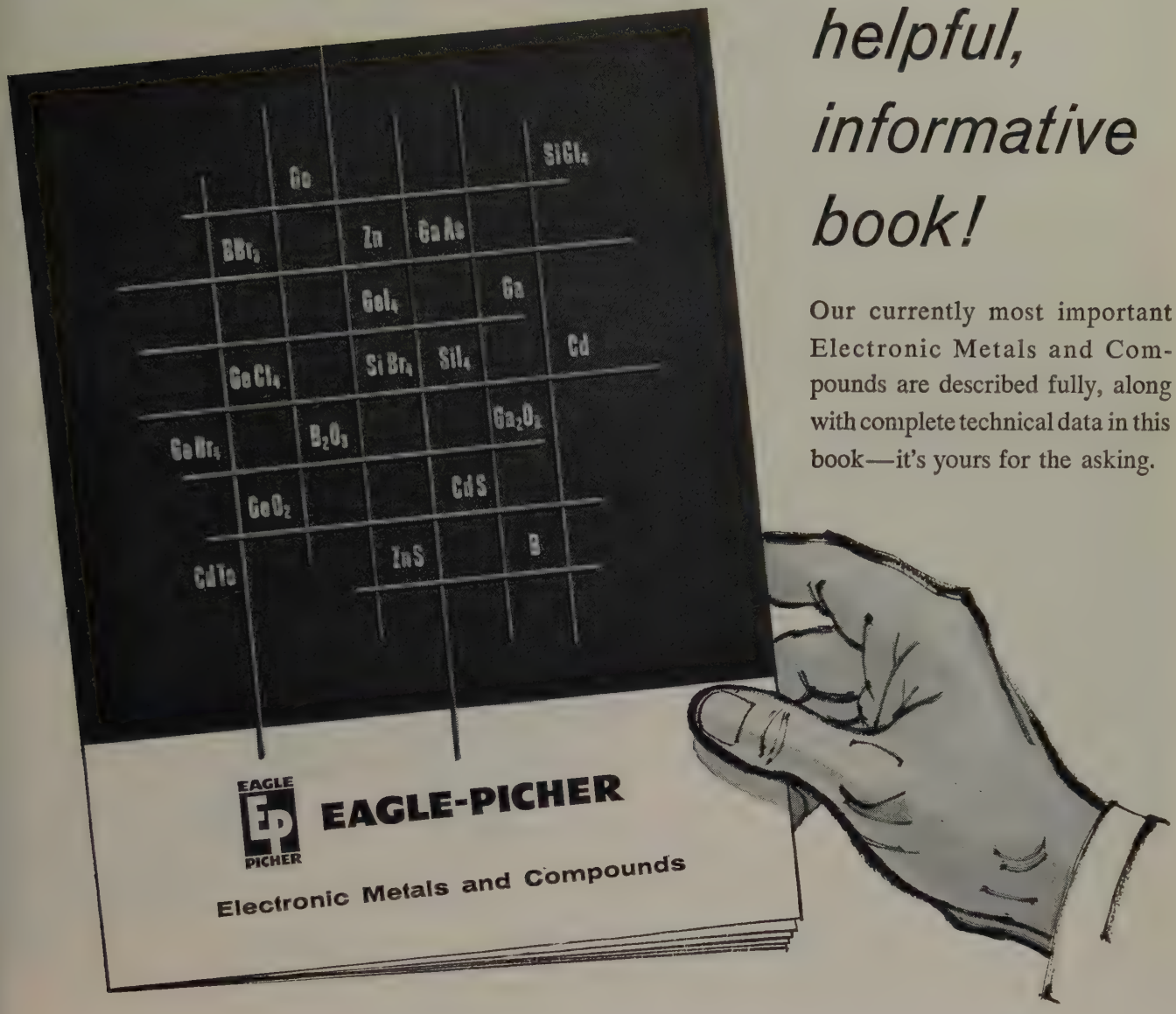

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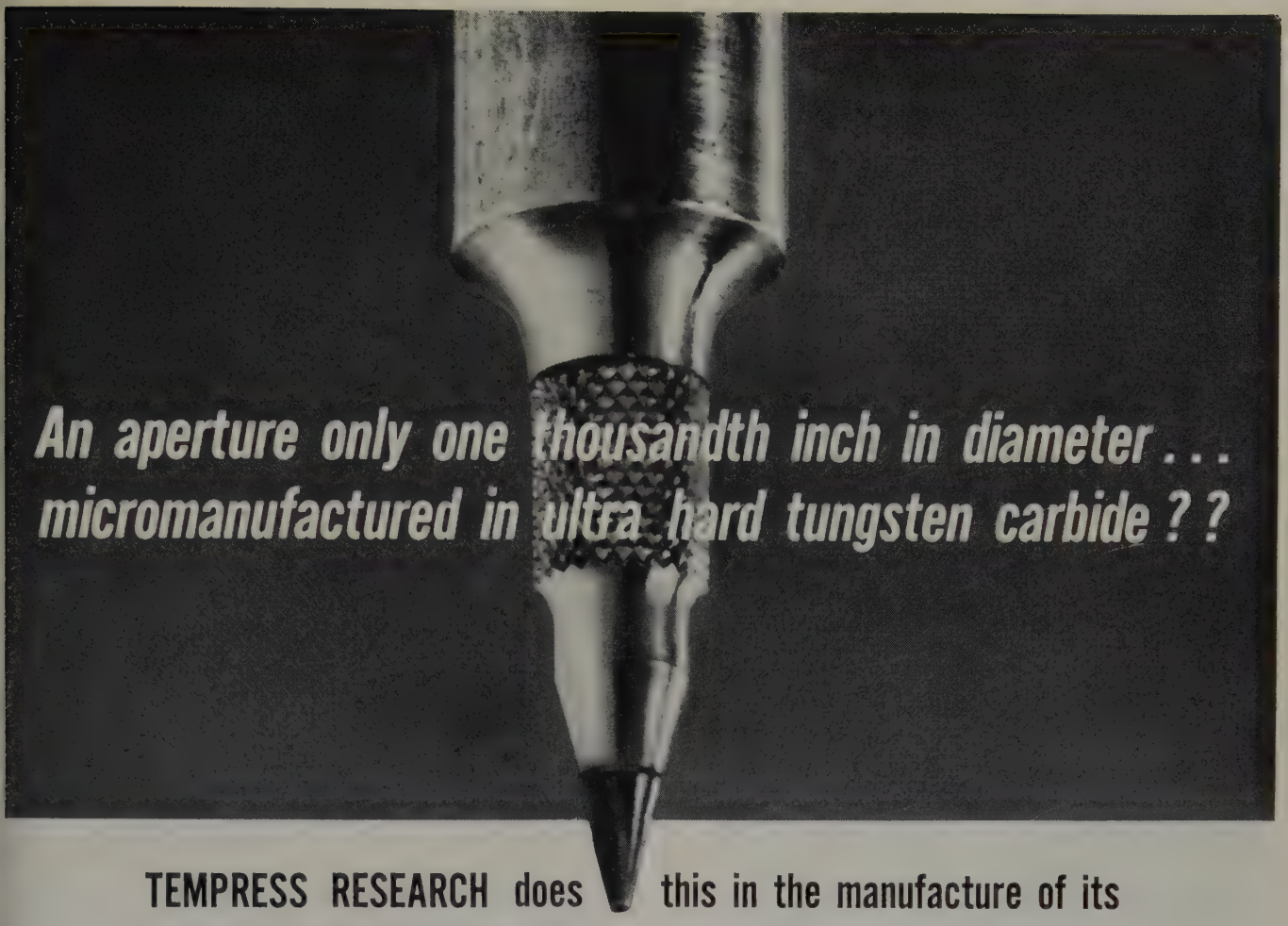

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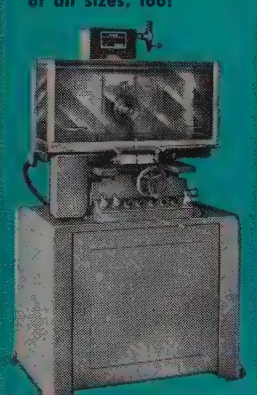

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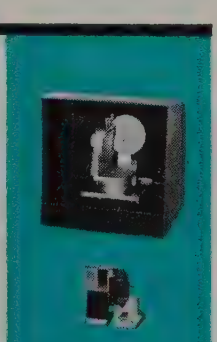

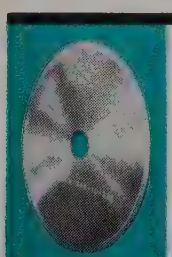

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Industry News

CONFERENCE CALENDAR

The Following December 1961 Meetings Are Scheduled:

Dec 12-14 EJCC (Eastern Joint Computer Conference), Sheraton Park Hotel, Washington, D. C. Sponsored by PGEC, AIEE, ACM. For Information: Bruce Oldfield, IBM Corp., 326 E. Montgomery, Rockville, Md.

Dec 27-30 AAAS Annual Exposition of Science & Industry, 128th Meeting, Denver Hilton Hotel, Denver, Colo.

For the second consecutive year, the U. S. Army Signal Corps has presented to General Instrument Corporation's Semiconductor Division its special award for quality production. The award, the RIQAP (Reduced Inspection Quality Assurance Plan) certificate, was given for General Instrument's "consistent production of high-quality electronic products for the armed forces" and the most rigid internal quality control procedures, which reduce the amount and cost of product inspection by the Government, it was stated.

RESEARCH and DEVELOPMENT

A cavity resonator has been developed at the National Bureau of Standards Boulder (Colorado) Laboratories for the study of millimeter radio waves. By using the Fabry-Perot interferometer as part of a resonator, the length of millimeter waves can be measured with great accuracy. Properties of materials, such as the dielectric constant of plastics, can also be studied with this device.

Tunnel-diode frequency converters may replace crystal mixers and eliminate pre-amplifiers in some UHF and microwave receivers, according to two engineers of the RCA Electron Tube Division. Outstanding features of the experimental devices are stability with input VSWR's exceeding 10:1 varied through all phases, low conversion losses, and low noise figures. Dr. Fred Sterzer and Adolph Presser said that they have demonstrated experimentally at UHF frequencies that stable tunnel-diode frequency converters can have lower conversion loss and lower noise figures than crystal-diode converters. It also is possible to obtain similar results at microwave frequencies. The engineers reported that they had built and tested several UHF converters, some broadband and some with built-in image-rejection filters. At an intermediate frequency of 30 mc, conversion losses ranged from 0 to 2 db, and noise figures were below 3 db. In discussing the theory of the new devices, the engineers pointed out that there is little likelihood that the noise figure of crystal mixers can be significantly improved by further research. On the other hand, they showed that for unity conversion gain, there is, in principle, no lower limit for the noise figure of tunnel-diode converters.

Millions of people in underdeveloped areas of the world can have new hope for an improved standard of living. A small self-contained electric power plant and pumping unit, capable of sustaining individual families or villages by irrigating the land they live on and supplying their household water needs, is the first step toward such progress, stated Dr. S. W. Herwald, vice president, research for Westinghouse Electric Corporation. A prototype of such a system, including a 50-watt power plant, has been built and tested. Developed in cooperation with the Solar Energy Laboratory of the University of Wisconsin, the experimental unit taps the heat energy of sunlight and converts it directly into electricity by means of a thermoelectric generator. The power generated drives an electric motor having a water pump connected directly to it. These are the only moving parts in the whole irrigation system.

A larger solar-thermoelectric system, scaled up from the 50-watt version, is now under development and has been operated at part power. This unit will have a capability of up to 200 watts of electric power. It will pump enough water from a depth of 20 feet to irrigate approximately four acres of land at the rate of 24 inches of water a year. This is about the average annual amount of precipitation in Minneapolis or Honolulu. The unit can supply the personal needs of 1200 people on the basis of five gallons of water per person per day.

To provide the stated amount of water, the system must operate 10 hours a day for only 250 days of the year. This leaves a safety margin of about one-third of the year to provide for cloudy weather, when the solar-thermoelectric generator would not operate. The solar-thermoelectric system uses an eight-foot saucer-shaped (parabolic) mirror which gathers the sunlight and focuses it on the thermoelectric generator. The generator is a metal "box" about eight inches on a side and about two inches thick. One face is black, to more efficiently absorb the heat of the sunlight shining upon it. Inside the generator are 72 thermoelectric elements, or couples, each composed of a "leg" of p-type semiconductor material and one of n-type. Like all thermoelectric materials, they have the unique ability to generate an electrical voltage when heated to a higher temperature on one side than on the other. The 72 thermoelectric couples are connected together electrically in series so that their voltages add together. The entire generator, which weighs just over 16 pounds, was fabricated at the Westinghouse semiconductor department. The generator can operate with temperatures on its hot side as high as 1100° F. However, in order to extend generator lifetime and reduce the initial cost of the system, especially the mirror, an operating temperature of 840° F (about twice the broiling temperature in a kitchen range) has been adopted. The cool side of the generator runs at 150° F.

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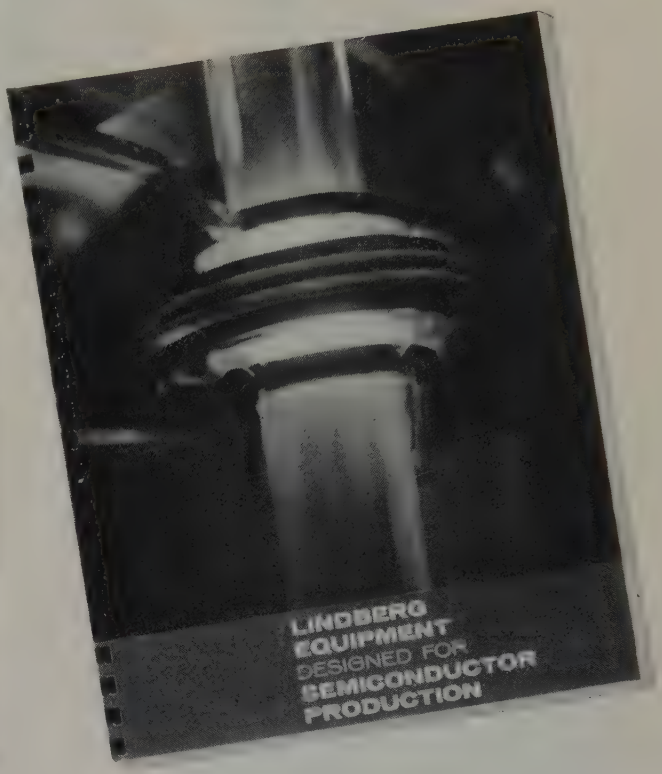

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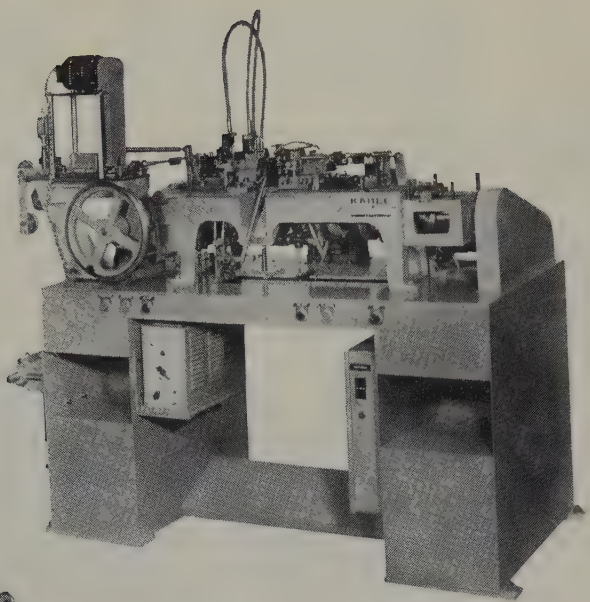

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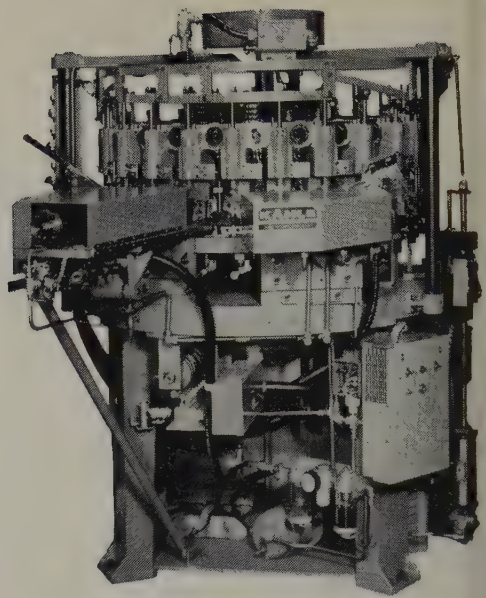

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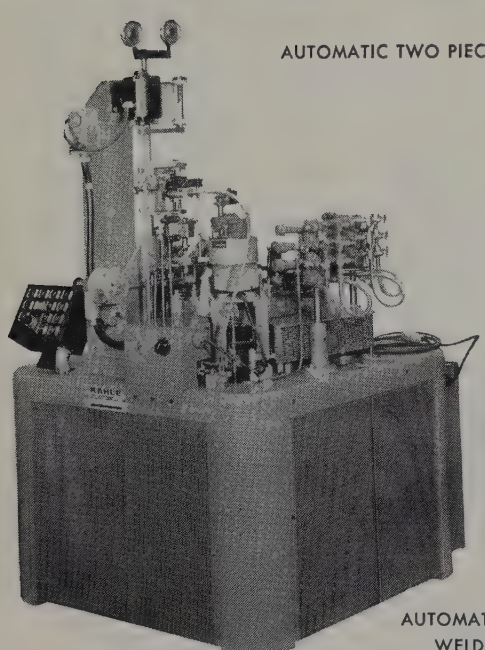

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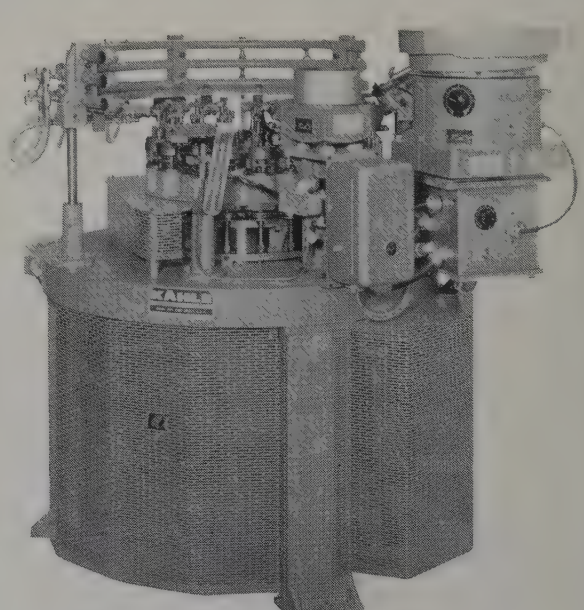

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Editorial . . .

Effective as of this issue Semiconductor Products will no longer publish the New Diode and Transistor Charts, each of which appeared bimonthly.

Optical Properties of Semiconductors

When a photon of energy greater than the energy gap is absorbed in a semiconductor, a hole-electron pair is produced and the hole and the electron travel separately as independent charges through the crystal. Depending on their lifetime and on their respective mobilities, the semiconductor conductivity is modified. By application of a suitable bias the carriers may be collected and utilized for the detection of the impinging radiation and of its modulation spectrum.

The response of such detectors is a complex function of the intensity of illumination, of the rate of recombination of the liberated holes and electrons, of the trap concentration and of the trap ionization levels. For example, while in the absence of traps the response time to pulse illumination is of the order of the lifetime of the carriers, in the presence of suitable traps it is increased by a factor as large as 10^8. If the ratio of the number of collected carriers to the number of absorbed photons is called the gain of the photoconductor, it is found that this quantity is given by the ratio of the response time to the carrier transit time between the electrodes.

As an example, good gains with germanium photodetectors have been obtained by counterdoping p-type Mn-doped germanium with donor impurities so that the resulting sample was n-type with double acceptor levels filled with electrons. Under photon absorption the liberated holes are captured by the acceptor levels and cannot recombine with the electrons. Gains of the order of 10^4 are found to occur in these conditions. On the other hand, very short response times are desirable when a wide band frequency response is needed. For such purposes, and to as close a degree as possible the response time should be made equal to the carrier lifetime. The latter should also be made sufficiently short with proper semiconductor techniques. It can be seen that response times of the order of nanoseconds are required to provide frequency response bandwidths of the order of kilomegacycles.

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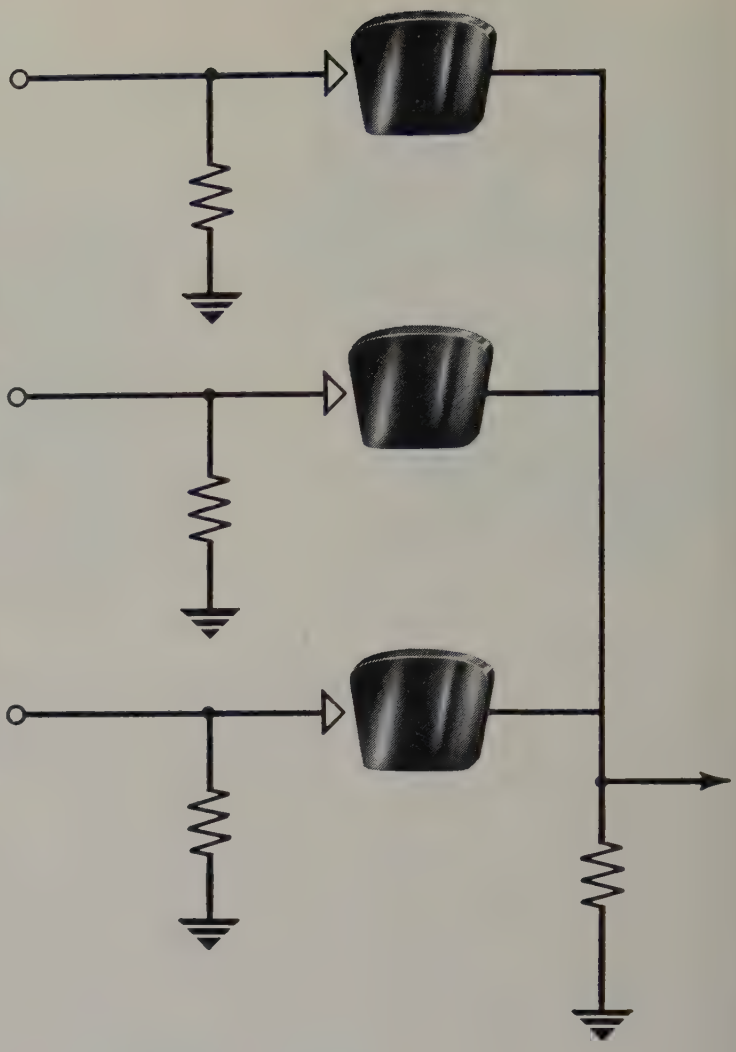

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Breakdown Voltage In Power Transistors

RALPH GREENBURG*

Second breakdown voltage can cause collector to emitter shorts and is the true maximum rating of a power transistor. The manner in which second breakdown occurs results in a derating of maximum allowable collector voltage as a function of collector current. Thus a safe operating area exists which in general is not a rectangle. Other breakdown voltage ratings, although nondestructive, can cause malfunctions of circuit performance. An expression has been developed which relates collector diode breakdown (BV_{CBO}) to other avalanche effects such as BV_{CEO}. The variables in the expression are BV_{CBO} and the internal and external resistors in series with the internal base-emitter junction. A possible explanation of the negative resistance area of the BV_{CES} characteristic is presented.

THERE ARE TWO MAIN FACTORS which cause collector current instability. One, which is quite well understood, is temperature, and much has been written on this subject. The second cause of instability is voltage, and although many papers have concerned themselves with this factor, it is much less understood than temperature-induced effects.

At least four simple voltage-current instability considerations are associated with power transistors. These are:

1. Second breakdown of collector
2. BV_{CBO}, breakdown voltage, collector to base, emitter open
3. BV_{CER}, breakdown voltage, collector to emitter, (Where R is any value from 0 to ∞)
4. V_{PT}, punch-through voltage.

The body of this article concerns second breakdown; the remaining three considerations are discussed in the appendix.

Second Breakdown

The manner in which collector voltage affects collector current results in an I_C-V_{CE} derating area for safe operation. The phenomenon which mainly determines the maximum reliable V_{CE}-I_C limits is called "second breakdown." Other breakdown voltages exist and a discussion of these will be found in the appendix, but second breakdown can cause destruction of the device and hence is the limiting factor. Second breakdown is associated with the collector-base junction, and is controlled by the emitter-base junction. The electrical interplay of the junctions is such that second breakdown is triggered at lower collector voltages as the base drive voltage is allowed to go from positive to negative in a p-n-p, during which time collector current increases. As an example the $V_{EB} = 0$ curve is shown in Fig. 1a, which indicates both first and second breakdown areas. The locus of trigger points is shown in Fig. 1b.

The exact action of second breakdown is not known but seems to be associated with a sudden concentration of current into a small area. This concentrated current dissipates power in a very small volume which causes the temperature to exceed the melting point of the germanium-indium alloy. The two junctions can then flow together causing a collector-to-emitter short. Dissection of a shorted unit usually reveals a pinhole through the germanium die when the indium is "washed" away.

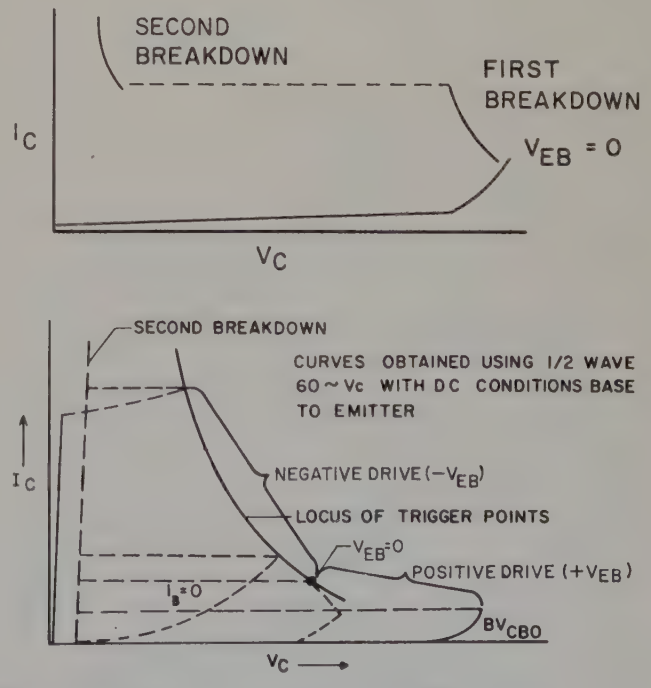

Fig. 1—(Upper) Typical second breakdown curve. (Lower) Locus of second breakdown voltage trigger points.

Applications Engineer, Motorola Inc., Semiconductor Products Division, Phoenix, Arizona

V_{CE}-I_C Derating Curves

The envelope generated by the second breakdown locus determines an absolute maximum V_{CE}-I_C limit which varies for each type of transistor. A typical case is illustrated in Fig. 2. A maximum reliability area will lie inside the absolute maximum area. This area is controlled in production by the proper transistor design and is assured by testing V_{CE}-I_C characteristics at two points. Point 1 on the curve is at the maximum continuous collector current and a low V_{CE} or actually in saturation (V_{CE} sat), during which time the base-emitter junction is heavily biased in the forward direction. The second V_{CE}-I_C condition (Point 2) is tested with the base connected to the emitter ($V_{EB} = 0$), while the collector voltage is swept with a step pulse or repetitive pulses such that the collector current is allowed to avalanche to a value of about 200 ma to 1 amp, depending on the transistor. This point also determines one of the absolute maximum limits. Another absolute condition (Point 3) is production-controlled by testing the collector diode voltage with the emitter open at some few milliamperes of collector current. The ability to withstand the peak current condition (Point 4) is designed into the device, and needs only sample testing.

The zone bounded by points 0, 3, 2, and 4 in Fig. 2 is set by the second breakdown locus of points, and is the "absolute maximum V_{CE}-I_C limit." The important boundary of this zone is a straight line approximation of the locus curve and is set conservatively below the trigger points. The zone bounded by points 0, 1, 2, and 5 is derated from the absolute limit to provide a maximum reliable area of collector operation. The areas described here apply to continuous and transient operation, if power-temperature derating is also obeyed. Continuous d-c operation must lie under whatever hyperbolic power curve is applicable at the particular mounting base temperature. Also, the peak power must not cause temperature rise above 100° C under any condition. However, the areas of V_{CE}-I_C safe operation are not temperature dependent. Thus, transient operation will always be safe as long as the proper deratings are applied.

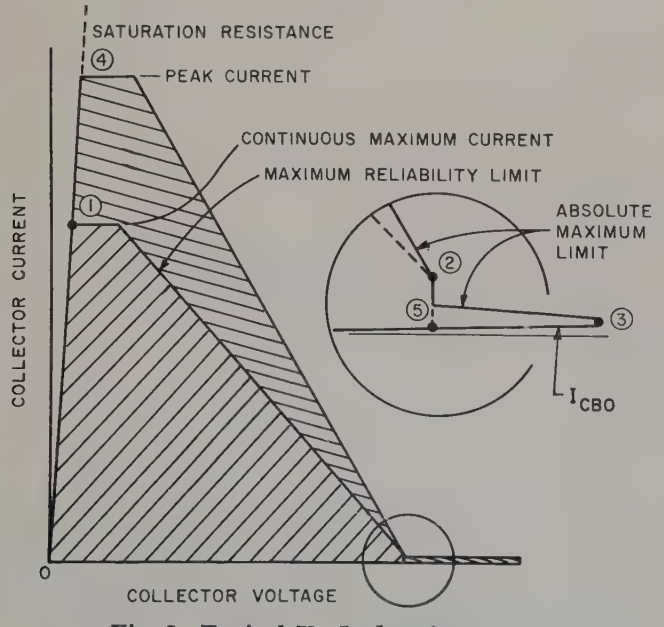

Fig. 2—Typical $V_{CE}I_C$ derating curve.

Applications

Operation beyond the maximum reliability area can endanger circuit performance, due to possible surges which would cause the load line to penetrate forbidden areas. The absolute maximum area must be obeyed completely, since second breakdown can be triggered within a few microseconds. For optimum performance the following suggestions should be followed:

1. Any low-frequency or continuous operation circuit, such as those for regulator use or audio amplifiers, should be operated under the power temperature derating curve at all times during the cycle. The safe $V_{CE} - I_C$ breakdown derating must also be observed.
2. D-C to A-C inverter applications must relate the average power and any surge power condition to the power-temperature derating curve. The switching interval, however, need concern itself only to the extent that the load line falls within the maximum reliability limits.
3. T-V horizontal output circuits or other tuned-circuit applications, which have L-shaped load lines may operate along the saturation resistance line during current surge and along the I_{CBO} line with voltage surges. This means that the maximum reliable area will be violated but the rule is modified with "L" shaped load lines. Of course, the "absolute maximum limits" still must be adhered to. Also, junction temperature should not exceed the maximum rating.

Examples

1. Consider a d-c to d-c converter with an average loss of 4 watts. There is a maximum collecter current of 10 amps and $V_{CE\ (max)}$ is 56 volts. Assume the load line appears as shown in Fig. 3.

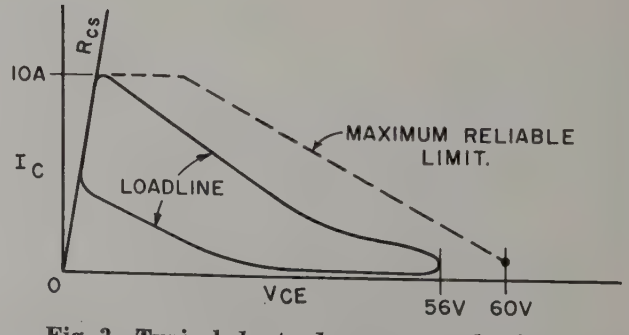

Fig. 3—Typical *d-c* to *d-c* converter load line.

The mounting base temperature must be held to less than 96°C with the proper heat sink since the thermal resistance of Motorola power transistors is 0.8°C/W. Use a 2N1551 since the load line falls within the safe area for this device.

2. Certain circuits will have in effect, an L-shaped load line, as shown in Fig. 4. With this type of operation the high-current spike hugs the R_{CS} line and the high-voltage swing can be held quite close to the I_{CBO} line. It is then permissible, with very high reliability assurance, to leave the maximum reliable limits and swing to the peak current and the BV_{CBO} point. However, the BV_{CBO} point should be respected and not used for limiting action such as that provided by a zener diode. If voltage spikes extend beyond BV_{CBO} on a recurrent or random basis, a zener diode should be placed from the collector to emitter to clip the spike.

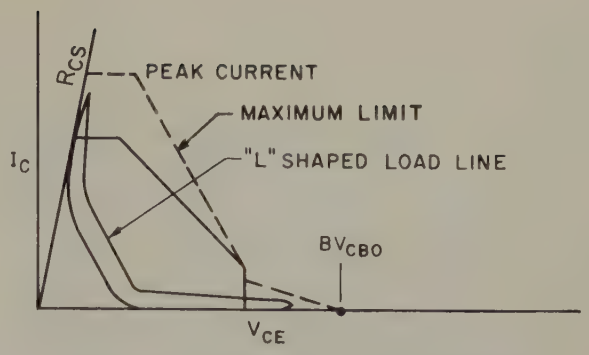

Fig. 4—"L" shaped load line operation.

APPENDIX

1. Collector to Base Breakdown (Emitter open)

BV_{CBO} is essentially the collector base diode breakdown and for p-n-p germanium alloyed-junction transistors follows the relation:

$$BV_{CBO} = 83.4\rho_b^{.61} \quad \text{(See Ref. 1)} \qquad (1)$$

where ρ_b is the resistivity of the base region.

The relation given by Equation 1 is not always encountered in power transistors since leakage current and a surface breakdown may occur first on a nonpredictable basis. Neither type of diode breakdown is destructive unless current is not limited, causing excessive power dissipation which could melt the junction. A typical diode breakdown voltage-current relation is shown in Fig. 5.

The slight rounding of the curve of Fig. 5 is due to the multiplication effect (m) which is related to avalanche voltage and collector voltage as expressed in Equation 2:

$$m = \frac{1}{1 - \dfrac{(V_{CB})^n}{(BV_{CBO})^n}} \quad \text{(Ref. 2)} \qquad (2)$$

The exponent "n" is empirically derived through observations, and at present cannot be given an exact value. It seems to depend not only upon the semiconductor material but also the geometry and type of junction (alloyed, diffused, etc). For alloyed germanium junction transistors the value of n has been observed to vary from 2 to 6. A value of $n = 3$ has given good results for n-type base material.

2a. Collector To Emitter Breakdown, Special Case (Base open, R = ∞)

The collector current path as a function of voltage with the base open, BV_{CEO} (Ref. 3) as portrayed in Fig. 6, is well known and is affected by BV_{CBO}, current gain, h_{FB}, and multiplication effect m. The relationship is:

$$I_C = \frac{mI_{C0}}{1 - mh_{FB}}. \qquad (3)$$

Combining Equations 2 and 3 and deleting an insignificant leakage effect, the collector current will be:

$$I_C = \frac{I_{C0}}{\dfrac{1}{1 + h_{FE}} - \dfrac{(V_{CE})^n}{(BV_{CBO})^n}} \qquad (4)$$

where h_{FE} is low voltage common emitter d-c current gain at the I_C in question.

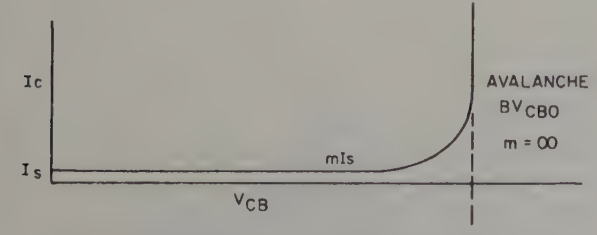

Fig. 5—Typical diode breakdown.

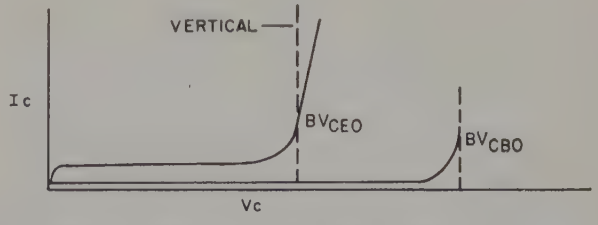

Fig. 6—Comparison of BV_{CBO} and BV_{CEO}.

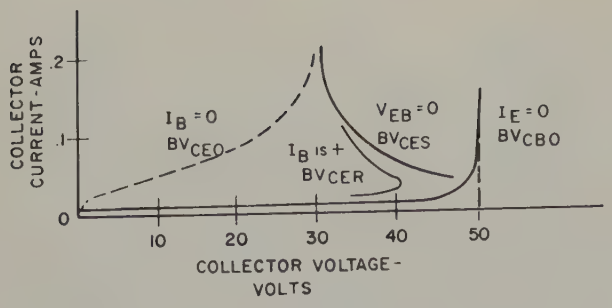

Fig. 7—General I_C versus V_{CE} breakdown.

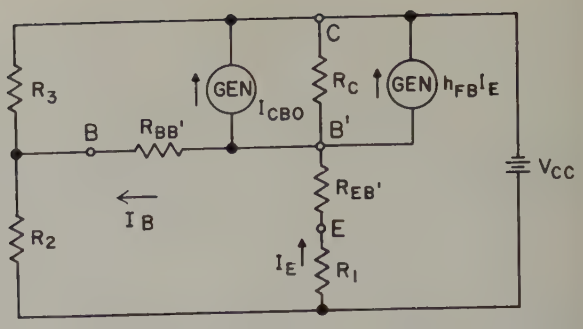

Fig. 8—Equivalent transistor and bias network.

Since I_C approaches infinity, i.e. avalanche, when the denominator of Equation 4 approaches 0, the following expression holds:

$$BV_{CE0} = \frac{BV_{CB0}}{\sqrt[n]{h_{FE} + 1}} = \frac{83.4\rho_b^{.61}}{\sqrt[n]{h_{FE} + 1}} \qquad (5)$$

The significant point in the relation of Equation 5 is that BV_{CE0} is independent of I_{C0}, although the current-voltage path to breakdown as expressed in Equations 3 and 4 is dependent. Also since h_{FE} decreases at high current, BV_{CE0} has a slight positive slope as indicated in Fig. 6. Certain transistors will have a slight negative slope in the BV_{CE0} curve at very low currents.

2b. Collector To Emitter Breakdown, Special Case (Base shorted to emitter, R = 0)

The third simple breakdown, shown in Fig. 7, occurs when the base is tied to the emitter. This is often called BV_{CES} and is the most commonly used maximum voltage rating. Generally, a negative slope will occur as an abrupt change in the BV_{CES} case, which will be explained in the following section.

2c. Collector To Emitter Breakdown, General Case

A general equation may be derived for the I_C versus V_{CE} curve for all conditions, namely base open, emitter open, and base-emitter shorted.

The equivalent circuit shown in Fig. 8 and simplified in Fig. 9 can be shown to be valid for a p-n-p transistor and its external bias resistors. The collector current for the equivalent circuit as a function of collector voltage and circuit parameters is:

$$I_C = \frac{mh_{FB}V_{BB} + h_{FB}mI_{CB0}(R_{BB'} + R_B)}{R_E + R_{EB'} + (R_{BB'} + R_B)(1 - mh_{FB})} \qquad (6)$$

where

$$R_B = \frac{R_2R_3}{R_2 + R_3},$$

$$V_{BB} = \frac{R_2V_{cc}}{R_2 + R_3}, \text{ and}$$

h_{FB} = low voltage common base current gain.

Combining Equations 2 and 6 (setting n = 3) and equating the denominator to zero so that I_C becomes infinite, the expression for the general collector breakdown voltage becomes:

$$BV_C = BV_{CB0}\sqrt[3]{1 - \frac{h_{FB}}{1 + \frac{R_E + R_{EB'}}{R_B + R_{BB'}}}} \qquad (7)$$

If the external emitter resistor, R_E, is allowed to approach infinity, BV_C will approach BV_{CB0}, which is the collector diode case (see Equation 1). If R_B approaches infinity, $BV_C = BV_{CB0}\sqrt[3]{1 - h_{FB}}$. Remembering that $(1 - h_{FB}) = 1/(h_{FE} + 1)$, this is seen to be the BV_{CE0} case (Equation 5). If both R_E and R_B are zero, the BV_{CES} case, then breakdown occurs when:

$$BV_C = BV_{CB0}\sqrt[3]{1 - \frac{h_{FB}}{\frac{R_{EB'}}{R_{BB'}} + 1}} \qquad (8)$$

It is known that under the BV_{CES} condition the voltage approaches BV_{CB0} (following the I_{C0} path), then reverses and approaches BV_{CE0} as current increases. The exact mechanism causing the negative resistance effect is rather complex since h_{FB}, $R_{EB'}$ and $R_{BB'}$ are functions of collector current. However, at very low I_C, the emitter diode resistance, $R_{EB'}$, is much larger than $R_{BB'}$, thus $BV_{CES} \approx BV_{CB0}$. As I_C increases, $R_{EB'}$ becomes smaller than $R_{BB'}$ and for large I_C, $BV_{CES} \approx BV_{CE0}$. The solution presented here is also valid where R_E and R_B are not zero and the resistance

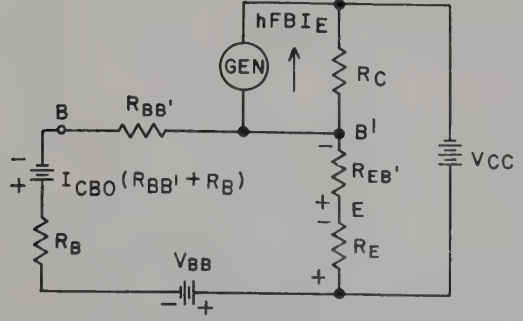

Fig. 9—Simplified equivalent circuit.

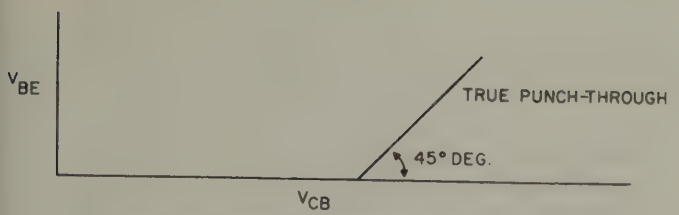

Fig. 10—Typical punch-through action.

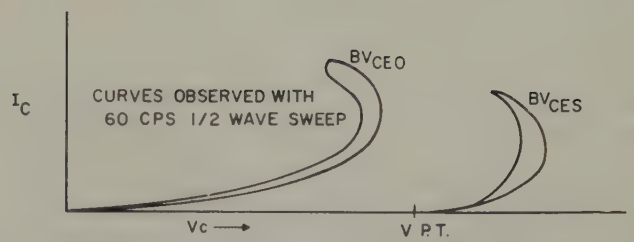

Fig. 11—Modification of BV_{CEO} and BV_{CES} curves due to low punch-through.

ratios can be fixed as desired such that the V_C versus I_C curves will follow all possible paths between BV_{CES} and BV_{CEO}. Voltages can replace the resistance to obtain the same effects. Also, I_{CBO} does not affect the breakdown voltage but does affect the path. For example, as temperature increases, the BV_{CES} path approaches the BV_{CEO} path.

3. Punch-Through (Emitter Open)

Another type of collector voltage effect, which is independent of the others discussed, is due to the collector space charge widening as voltage increases until it touches the emitter space charge region permitting the emitter voltage to follow the collector voltage. This effect has been labeled "Punch-Through." Transistor action ceases when this happens, but no real instability occurs. The BV_{CEO} and BV_{CES} curves will be modified if the punch-through voltage occurs near their value. Common cases of punch-through are shown in Fig. 10 and the modified BV_{CEO} and BV_{CES} curves are shown in Fig. 11. Punch-through follows the equation:

$$V_{PT} = \frac{630W^2}{\rho_b} \quad \text{(Ref. 1)} \qquad (9)$$

where

W = base width in mils, and

ρ_b = base resistivity in ohm-cm.

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The Technology of Pulling Single Crystals

HENRY T. MINDEN*

Part 1

This article is intended to give a practical feel for the technique of pulling semiconductor single crystals from the melt. The conditions for dipping the seed and increasing the diameter of the crystal are given. The nature of some of the difficulties which occur is discussed in terms of the thermal configuration of the puller. Some of the causes of imperfect growth are presented from a macroscopic empirical viewpoint. Finally, some of the special techniques required for compound semiconductors are presented.

ALMOST ALL SEMICONDUCTOR DEVICES are fabricated from single crystal material. The performance of these devices depends on the bulk properties of the material and also on the introduction of controlled impurity configurations. The grain boundaries of polycrystalline material usually have different electrical properties from those of the bulk crystal. For instance, they may short a p-n junction structure[1] or they may present a high resistance blocking layer to the current flow.

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Grain boundaries interfere with the fabrication of devices. One of the techniques used to form p-n junctions is to diffuse an impurity into the material. It is well known that impurities diffuse more rapidly along grain boundaries than through the crystal.[2] As a result, a diffused junction in polycrystalline material is quite irregular. Another technique of forming junctions is to alloy a metal dot with the semiconductor and then to allow doped material to recrystallize. If the dot crosses a grain boundary, the boundary region will dissolve faster than the bulk, and again an irregular junction will form on recrystallization.

In most semiconductor devices, excess current carriers are injected into and diffuse across certain regions of the crystal. The characteristics of the devices are governed by the length of time (lifetime) that the non-equilibrium carrier concentration can be maintained. Grain boundaries catalyze the decay to equilibrium[3] and hence are deleterious to device performance.

Not only must the semiconductor crystals be single, but they must be crystallographically oriented with respect to the geometrical configurations of the p-n junctions. The alloying process and the etching process occur at different rates along different crystallographic directions. In general the p-n junctions are formed so as to coincide with the (111) crystallographic plane for germanium and silicon.

For these many reasons, the technology of growing large, well-oriented single crystals is a major factor in the semiconductor industry. One of the most widely used techniques is the Czochralski pulling[4] method (Fig. 1). The semiconductor is melted in a crucible; the temperature is such that the liquid surface is just above the freezing point. A small, crystallographically oriented seed is dipped into the melt, and the liquid adheres to the seed by surface tension. As the seed is slowly raised, the crystal will be propagated; under the correct conditions it will grow to a diameter which is considerably larger than that of the seed.

A great deal has been written about the apparatus[5] used for crystal pullers. In fact, commercial crystal pullers are readily available. Some papers have been concerned with specific details of the method, but very little has appeared on the theory of the technique. Doubtless much literature on this subject floats in the limbo reserved for company memoranda, and of course, anyone who actually grows crystals soon acquires a good intuitive grasp of the principles involved.

This article represents an attempt to formalize and bring to light some of these principles. Particular consideration will be paid to the temperature configuration of the system. The technique of dipping the seed will be given, and the method for increasing the diameter will be presented. Causes of twinning and polycrystallinity will be pointed out. Finally some of the special problems will be discussed which are concerned with the growth of compound semiconductor crystals.

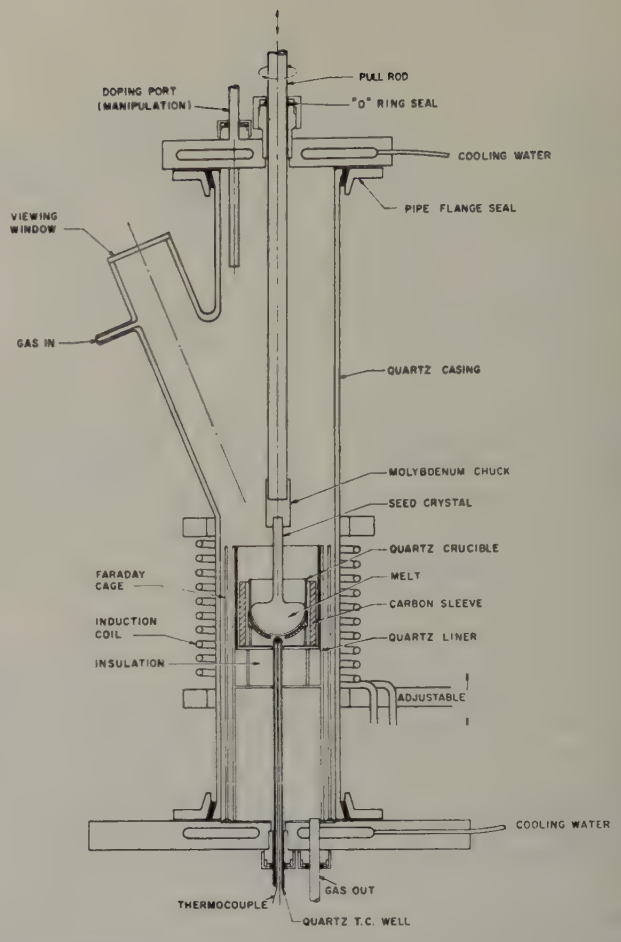

Fig. 1—Schematic diagram of a conventional crystal puller.

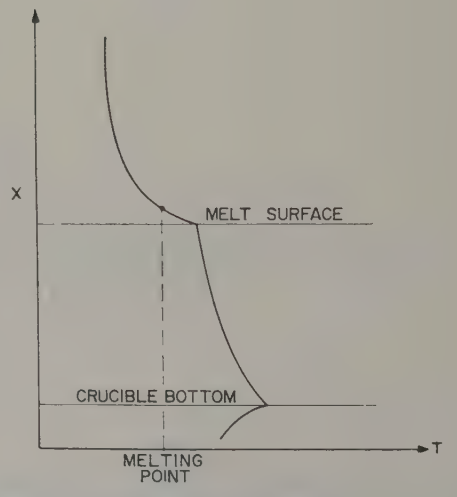

Fig. 2—Vertical temperature profile of a crystal puller. Note that the melting point lies slightly above the liquid surface. The temperature of the melt continues to increase with depth below the surface.

Propagating the Seed

At the start of a run the charge in the crucible is melted and brought to a temperature which is 15°-20° above the freezing point; this destroys the incipient freezing nucleii. The temperature is lowered until the

melt surface is just a few degrees above the freezing point. The freezing isotherm is then located about $\frac{3}{16}''$ above the surface as shown in Fig. 2. The seed is held for a while at a position just above the surface. This allows the seed to warm up. If the cold seed is dipped into the melt, spontaneous crystallization will occur. When the seed is hot, it is dipped into the liquid. The end of the seed melts up to the position of the freezing isotherm. The liquid wets the seed and adheres to it so that a truncated cusp is formed as shown in Fig. 3. The dotted line shows the liquid cusp which would be formed on an infinitely narrow seed. The diameter of the crystal which propagates will be essentially the diameter of the cusp at the freezing isotherm.

If the diameter of the seed is greater than the diameter of the cusp at the melting isotherm as shown in Fig. 4a, the seed will be pointed by the melting process. If, on the other hand, the diameter of the seed is less than the cusp diameter at the freezing interface as shown in Fig. 4b, the liquid will spontaneously freeze onto the seed until the solid has the diameter required by the thermal configuration. This freezing is usually dendritic in nature, and the button is almost always polycrystalline. In such a case the melt temperature is increased enough to raise the freezing isotherm to a level on the hypothetical cusp where the cusp diameter is less than the seed diameter. Physically, as the temperature is raised, the polycrystalline belt will melt and the seed will eventually be pointed. If the freezing isotherm is too high on the cusp, of course, the surface tension will no longer suffice to support the liquid, and the melt will part from the seed. A skilled operator knows intuitively the melt temperature which is required to prevent spontaneous regrowth.

Once the proper dipping condition has been established, the seed is slowly raised. The effect of the pulling is to narrow the hypothetical cusp as shown in Fig. 5. The faster the pull rate, the narrower the cusp becomes, until the melt parts from the seed. In practice pull rates of from ½ to 3 in/hr are used, and the pull rate is maintained constant.

In order to grow a large diameter crystal from the seed, it is obvious from Fig. 3 that the freezing isotherm must be lowered. Initially the diameter of the cusp at the freezing isotherm will determine the diameter of the crystal. Now from Fig. 3 it can be seen that if the isotherm is flat, it cannot be lowered indefinitely. When it coincides with the melt surface, the surface will freeze spontaneously. This flat isotherm catastrophe often occurs in practical crystal pullers without being recognized. The operator learns by experience how large a crystal can be grown without inducing the catastrophe. He has broken many seeds, seed holders and even crucibles in the learning process, and in the end he usually must be content with a crystal diameter which is much smaller than that of the crucible.

As the term implies, the flat isotherm catastrophe

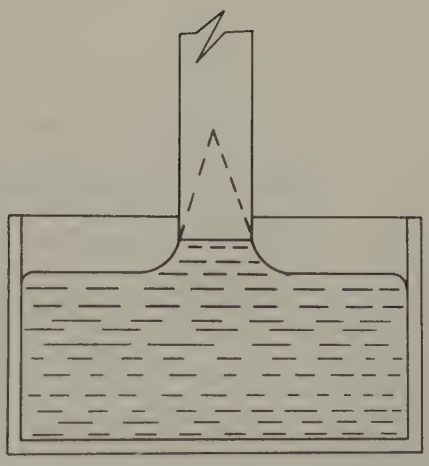

Fig. 3—Truncated liquid cusp which rises to the dipped seed.

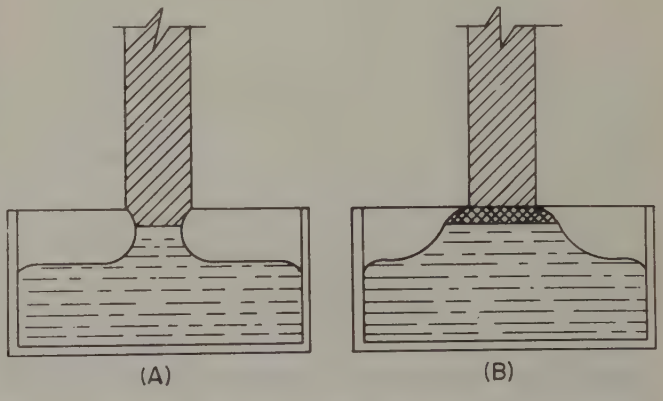

Fig. 4—Relation between seed diameter and the diameter of the cusp at the freezing isotherm. (a) When the seed diameter is greater than cusp diameter, the seed is melted down. (b) When the seed diameter is greater than the cusp diameter, a polycrystalline section (shown at arrow) freezes.

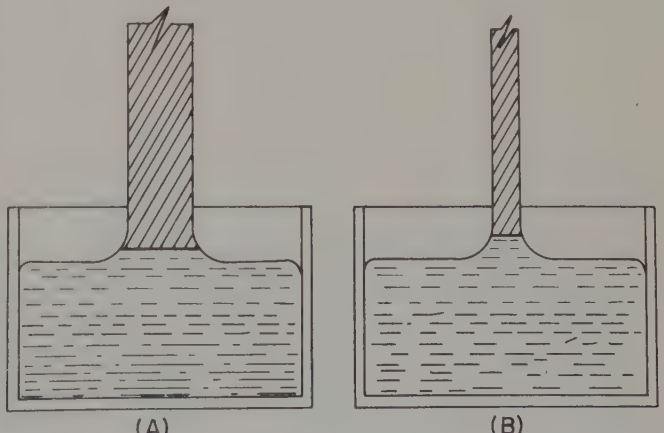

Fig. 5—Effect of pull rate on liquid cusp. (a) Slow pull rate. (b) Fast pull rate. The cusp is narrower and the freezing interface is farther from the melt surface.

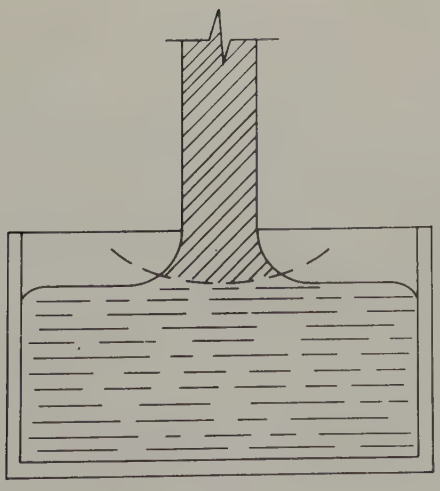

Fig. 6—Determination of the crystal diameter by the dish-shaped isotherm.

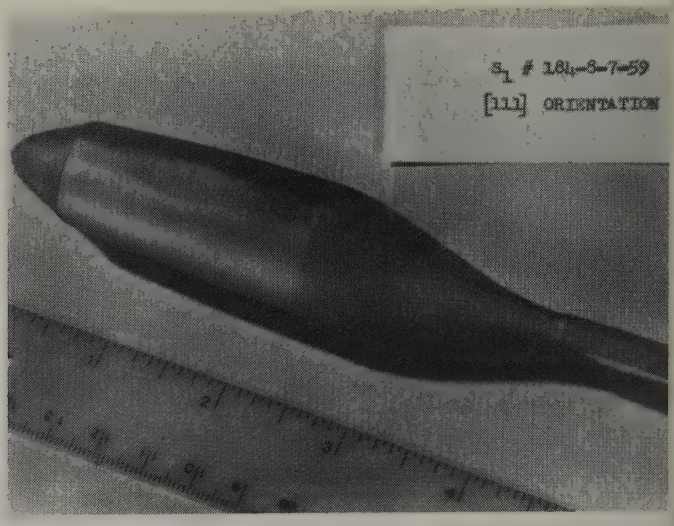

Fig. 7.—Pulled crystal showing a flat face.

can be avoided by designing the puller in such a way that the freezing isotherm is dish-shaped as shown in Fig. 6. The circle of intersection between the isotherm and the melt surface determines the diameter of the crystal. In this case, of course, the diameter of the crystal is limited only by the size of the crucible. If a growing crystal is suddenly pulled clear of the melt, a circular island will crystallize and remain centered at the surface of the melt. In fact, even before the seed is dipped, the proper operation of the furnace can be checked by lowering the melt temperature until the melt surface just begins to crystallize. The formation of a centered, circular island indicates a satisfactory furnace design.

Even with the dish-shaped freezing isotherm, caution must be observed as to the rate at which the temperature is lowered in the attempt to increase the crystal diameter. Inherently there is a maximum permissible time rate at which the crystal diameter can be increased. If this rate is exceeded, spontaneous nucleation and dendritic growth will occur around the rim of the crystal. Let $T = F(r, z)$ be the three dimensional temperature profile in cylindrical coordinates. Then:

$$\frac{dT}{dt} = \frac{\partial T}{\partial r}\,\frac{dr}{dt}$$

at the melt surface (z constant). If the maximum lateral growth rate (dr/dt) is fixed, the rate at which the temperature can be lowered (dT/dt) is determined by the lateral temperature gradient $(\partial T/\partial r)_z$. This is a property of the furnace design. The flat isotherm catastrophe is the case for which $(\partial T/\partial r)_z = 0$. A large value of this gradient is clearly desirable. At $r = 0$, of course, the gradient is zero, and at the radius of the seed it is still small. Part of the art of crystal growing lies in knowing just how fast the temperature control point can be lowered after the seed is caught without inducing polycrystallinity.

After the desired crystal diameter has been achieved, the control point usually must be continually lowered to maintain that diameter. As the crystal is grown, the liquid level sinks in the crucible. Since the temperature increases with the depth, the freezing isotherm rises with respect to the surface of the melt. Therefore, if the temperature were not lowered during the growing process, the crystal diameter would taper towards the last-to-freeze end. Now there is no particular aesthetic objection to a tapered crystal. In growing a doped crystal however, a taper may introduce an unwanted variation of resistivity with length. The proper programming of temperature control is one of the important factors in puller design.

As we already pointed out, the surface of the melt rises up to the growing crystal in sort of a truncated cone. The cross section of this cone is circular because of the surface tension of the liquid, and as a consequence, the crystal cross section tends also to be circular. Portraits of gleaming, sausage-like crystals of germanium and silicon are quite familiar by now to those who have been exposed to the literature of the semiconductor industry. A growing crystal tends to freeze, however, in a so-called natural habit with flat crystal faces. If the crystal is grown rapidly so that the freezing isotherm is quite far above the normal melt surface, the force of surface tension will dominate, and the crystal will have a cylindrical shape. If, on the other hand, the crystal is pulled slowly so that equilibrium freezing conditions are approached, the crystal instead of being cylindrical will tend to be prismatic—bounded by flat faces as shown in Fig. 7. When a cubic crystal such as germanium is grown in the (111) direction, for instance, the cross section will approximate an equilateral triangle, because the crystal is pulled somewhat faster the corners will become rounded and only ridges will be left at the sides of the triangle. In production crystals are almost always grown at a sufficiently fast rate so as to produce cylinders.

(To be continued)

An Analysis of The D-C Design Considerations of a Transistorized Schmitt Trigger

Part 1

JACK CORSIGLIA*

In the design of a transistorized Schmitt trigger one can embark upon quite a tail-chasing episode if he expects to change only one parameter to achieve a desired result. Often a compromise must be reached between dead band, trip point, and swing in output voltage. In some instances another stage may be required to complete the desired function. A sound design approach is to establish first the necessary requirements, and second the desirable requirements. In this manner the number of variable parameters is minimized.

THE SCHMITT TRIGGER is a regenerative circuit capable of assuming either of two stable conducting states, dependent upon the input voltage amplitude. If the input is below a predetermined d-c level, referred to as the lower trip point (LTP), the input or first stage will be off and the second stage will be conducting. When the input voltage is above the pre-determined d-c level, plus an additional dead band, the input stage will be conducting and the second stage will be off. The point at which the latter stable state is assumed is referred to as the upper trip point (UTP). The output is normally taken from the collector of one of the two transistors.

Applications of the Schmitt trigger include analog-to-digital conversion, level sensing, level shifting, and voltage comparison. It can be used as a pulse counter, a sync driven multivibrator, a rectangular waveform generator, a gate generator, or a relay trip circuit. The circuit is also useful for squaring sinusoidal, sawtooth, and other waveshapes, or re-establishing a d-c level.

The Schmitt trigger circuit differs from the monostable or "one-shot" multivibrator in that the cross-coupling is d-c for a Schmitt trigger, and the Schmitt trigger output remains in one binary state as long as the input voltage excursion does not traverse the region from the upper trip point to the lower trip point, or conversely. The Schmitt trigger is a level sensitive circuit. The mono-stable multivibrator is a-c cross-coupled and is a time delay device which will give an output pulse a prescribed period of time after an input trigger has been received.

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A comparison is shown in Fig. 1, between a vacuum-tube and a transistorized version of the Schmitt trigger circuit (sometimes called a cathode-coupled binary circuit). The circuit operation is as follows: Assume that the input voltage is zero and that Q_1 is biased off and Q_2 is in full conduction. This will be true because the current flowing through either transistor at "turn on" will develop a bias across R_E which will cause Q_1 to be reverse biased and the voltage divider consisting of R_{c1}, R_1, and R_2 will cause Q_2 to be forward biased, and thus will ensure that Q_2 will be in conduction. If the input voltage is less than the voltage across R_E, the Schmitt trigger circuit will remain in the above described binary state.

The Upper and Lower Trip Points

The upper trip point occurs when the input voltage becomes greater in magnitude than that across R_E by an amount sufficient to forward bias the emitter-base junction and provide a base current into Q_1. Q_1 will then be forward biased and will start to conduct. As

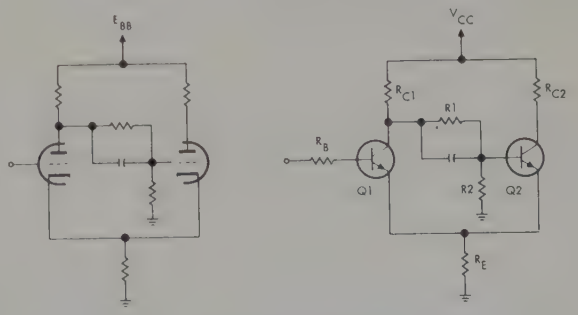


Fig. 1—Vacuum tube and transistor analogy of a Schmitt trigger circuit.

Q_1 begins to conduct, the voltage from collector to ground at Q_1 begins to fall toward zero. As this voltage is reduced in magnitude, the voltage at the base of Q_2 is reduced and subsequently, the base drive current into Q_2 is reduced. As Q_2 begins to come out of saturation, the voltage from emitter to ground falls toward zero. This decrease in emitter voltage, with the input voltage constant, increases the voltage from emitter to base of Q_1. This process repeats itself and becomes regenerative when the loop gain exceeds unity. The circuit thus will transfer rapidly from one binary state to the other.

The voltage level at which the LTP occurs is not the same as for the UTP. There is a hysteresis[1] or dead band caused by different circuit parameters for the two stages. First, the base voltages of Q_2 is governed by the voltage divider formed by R_{C1}, R_1, and R_2. The base voltage of Q_2 will be at one of two discrete levels, since the collector of Q_1 will have two discrete levels corresponding to the upper and lower trip conditions. Second, since the base of Q_2 will be at one of two different d-c levels, the emitter-base junction of Q_2 will be either forward or reverse biased. It is this combination of two separate and distinct voltages across R_2 and R_E, corresponding to Q_1 conducting or Q_2 conducting, that results in a separation or dead band between the two trip points.

The lower trip point is approached by an input voltage of decreasing magnitude under the condition of Q_1 conducting and Q_2 off. The input voltage now must turn Q_1 off. In order to do this, the input voltage must drop below the magnitude of the voltage across R_E plus an additional drop corresponding to V_{EB} of Q_1. When this lower trip point has been reached by the input voltage, the same regenerative action occurs as previously described for the upper trip point and the circuit will again change to its opposite binary state.

Calculation of the Upper Trip Point

An expression for the upper trip point (UTP) in terms of the input voltage can be derived by letting:

$$V_{in} = V_E + V_{EB1}$$

where V_E is the voltage from ground to emitter and V_{EB1} is the emitter to base voltage of Q_1.

If it can be assumed that Q_2 is well in saturation, and I_{B2} is negligible compared with I_{E2}, then:

$$I_{E2} \approx I_{C2} \text{ and } V_E = \frac{R_E}{R_{C2} + R_E} V_{CC}$$

Therefore, an approximation for the UTP is:

$$UTP = \frac{R_E V_{CC}}{R_{C2} + R_E} + V_{EB1} \qquad (1)$$

If it cannot be assumed that I_{B2} is negligible compared with I_{E2}, then a more exact representation of the UTP shall be derived from the equivalent circuit

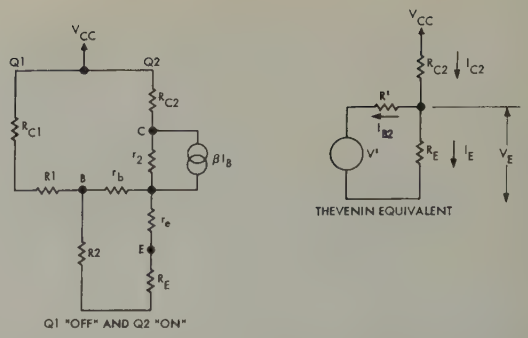


Fig. 2—AC equivalent of Schmitt trigger circuit.

shown in Fig. 2, (it is assumed that there is a negligible leakage current I_{CEO} in Q_1):

$$V_E = I_E R_E$$

$$I_E = I_{C2} + I_{B2}$$

$$I_{C2} = \frac{V_{CC} - V_{C2}}{R_{C2}}$$

where V_{C2} is the voltage from ground to collector of Q_2.

Further, if Q_2 is well in saturation:

$$V_{C2} \approx V_E$$

If the input to the base of Q_2 is treated as a Thevenin generator, the open circuit voltage is:

$$V' = \frac{R_2 V_{CC}}{R_{C1} + R_1 + R_2}$$

The internal resistance is:

$$R' = \frac{R_2 (R_{C1} + R_1)}{R_{C1} + R_1 + R_2}$$

Assuming that $r_b << R'$, the base current of Q_2 is:

$$I_{B2} = \frac{V' - V_{B2}}{R'}$$

where V_{B2} is the voltage from ground to the base of Q_2:

$$V_E = I_E R_E = R_E \left[\frac{V_{CC} - V_{C2}}{R_{C2}} + \frac{V' - V_{EB2} - V_E}{R'} \right]$$

Solving for V_E and simplifying:

$$V_E = \frac{R_E [R' V_{CC} + R_{C2} (V' - V_{EB2})]}{R_{C2} R' + R_E R' + R_E R_{C2}}$$

Substituting V' and R' in the above and simplifying gives Eq. 2. (See top of p. 31)

Neglecting the effect of loading, the swing in output voltage is approximately:

$$\Delta V_O = V_{CC} - V_E \qquad (3)$$

$$V_E = \frac{R_E R_2 V_{CC} (R_{C1} + R_{C2} + R_1) - R_E R_{C2} V_{EB2} (R_{C1} + R_1 + R_2)}{R_{C2} (R_{C1} + R_1) (R_E + R_2) + R_E R_2 (R_{C1} + R_{C2} + R_1)}$$

$$UTP = \frac{R_E R_2 V_{CC} (R_{C1} + R_{C2} + R_1) - R_E R_{C2} V_{EB2} (R_{C1} + R_1 + R_2)}{R_{C2} (R_{C1} + R_1) (R_E + R_2) + R_E R_2 (R_{C1} + R_{C2} + R_1)} + V_{EB1} \quad (2)$$

Calculation of Lower Trip Point

In a similar manner, an expression for the lower trip point can be derived, assuming that Q_1 is in saturation and that the base current of Q_2 is small compared with the bleeder current of R_{C1}, R_1 and R_2:

$$LTP = V_E + V_{EB1} \text{ and } I_E \approx I_{C1} =$$

$$\frac{V_{CC} - V_{C1}}{R_{C1}} - \frac{V_{C1}}{R_1 + R_2}$$

But, if Q_1 is in saturation, $V_{C1} \approx V_E$:

$$I_E = \frac{V_{CC}}{R_{C1}} - \frac{V_E}{R_{C1}} \left(1 - \frac{R_{C1}}{R_1 + R_2}\right)$$

Solving for V_E and simplifying gives:

$$V_E = \frac{R_E (R_1 + R_2) V_{CC}}{R_E (R_{C1} + R_1 + R_2) + R_{C1} (R_1 + R_2)}$$

$$LTP = \frac{R_E (R_1 + R_2) V_{CC}}{R_E (R_{C1} + R_1 + R_2) + R_{C1} (R_1 + R_2)} + V_{EB1} \quad (4)$$

Flexibility of the Circuit

It should be noticed that the lower trip point is relatively independent of R_{c2} and of the transistor parameters. The key to all of the solutions for the UTP and the LTP is to express V_E in terms of the other circuit parameters. The value of V_E is different when Q_1 is conducting (LTP) compared with the condition when Q_2 is conducting (UTP). A circuit using 5 percent resistors is shown in Fig. 3. The numerical value for V_E, corresponding to the UTP (Equation 2), was calculated as 1.42 volts and measured as 1.40 volts. V_E, corresponding to the LTP (Equation 4), was calculated as 0.9 volt and measured as 0.89 volt. Thus, this circuit has a wide flexibility between both p-n-p and n-p-n germanium and silicon transistors and will accommodate wide ranges in beta. These facts are illustrated in Table I. The calculated value for the UTP was 1.7 volts (Equation 2), and the calculated value for LTP was 1.2 volts, using a value of 0.3 volt for V_{EB} for germanium transistors. For silicon transistors, the value for the UTP was calculated as 2.1 volts (Equation 2), and the LTP as 1.6 volts, using a value of 0.7 volt for V_{EB}. The value of h_{FE} was determined by adjusting a constant current generator to give a collector current of 12 ma and then varying the base current for a saturation voltage of $V_{Ec} = 0.15$ volt. h_{FE} was then calculated as $h_{FE} = I_C/I_B$.

Varying the Trip Point

It should be emphasized that the circuit responds only to input signals that traverse the region between the upper trip point and the lower trip point. Therefore, the input must be directly coupled into the base of Q_1 to obtain a faithful squaring action of the input waveform. If the input is capacitively coupled, a differentiation of the input signal will occur and a nonsymmetrical output will be obtained.

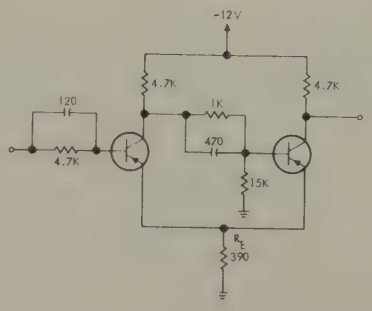


Fig. 3—Sample circuit used in the evaluation of Schmitt trigger characteristics.

Table I

JEDEC No.	Type	h_{FE} Q_1	h_{FE} Q_2	UTP	LTP	E_o@ UTP	E_o@ LTP
2N170	N-P-N	14	13	1.8	1.2	11.6	1.7
2N335	N-P-N-si	20	20	2.32	1.62	11.6	1.7
2N404	P-N-P	43	43	1.85	1.25	11.5	1.6
2N404	P-N-P	60	28	1.80	1.17	11.5	1.6
2N404	P-N-P	28	60	1.98	1.35	11.5	1.6
2N554	P-N-P (power)	39	41	1.7	1.35	9.9	1.6
2N585	N-P-N	86	84	1.9	1.25	11.6	1.6
2N600	P-N-P	150	120	1.72	1.1	11.6	1.6
2N652	P-N-P	120	100	1.75	1.15	11.6	1.6
2N1102	N-P-N	28	29	2.05	1.49	11.6	1.6
2N1301	P-N-P	30	20	1.95	1.28	11.6	1.7
2N1311	N-P-N	20	24	2.15	1.55	11.6	1.65
2N1371	P-N-P	63	59	1.85	1.28	11.6	1.6
2N1382	P-N-P	71	55	1.85	1.22	11.6	1.6
2N1605	N-P-N	66	65	1.95	1.35	11.6	1.6

The input-output voltage characteristics of amplifiers with various closed-loop gains are illustrated in Fig. 4. In Fig. 4(a), where the closed-loop gain is greater than 1, it can be seen that a negative-resistance region (dead band) exists between the lower trip point and the upper trip point. In Fig. 4(b), where the loop gain equals 1, the dead band is diminished to zero. If the loop gain is less than 1, Fig. 4(c), the circuit will behave as a linear amplifier, and the input-output voltage characteristic will no longer possess a negative slope, but rather will have a positive slope between the lower trip point and the upper trip point. It becomes obvious then that some dead band must exist in order to provide a negative resistance region and thus ensure a fast transition, or toggle action, from one binary state to

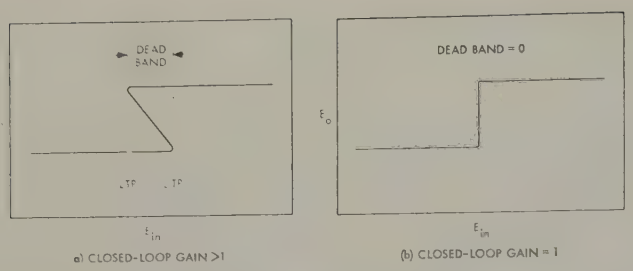
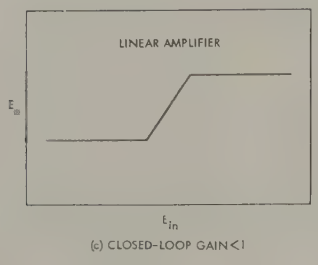


Fig. 4—Comparison of deadband and closed loop gain.



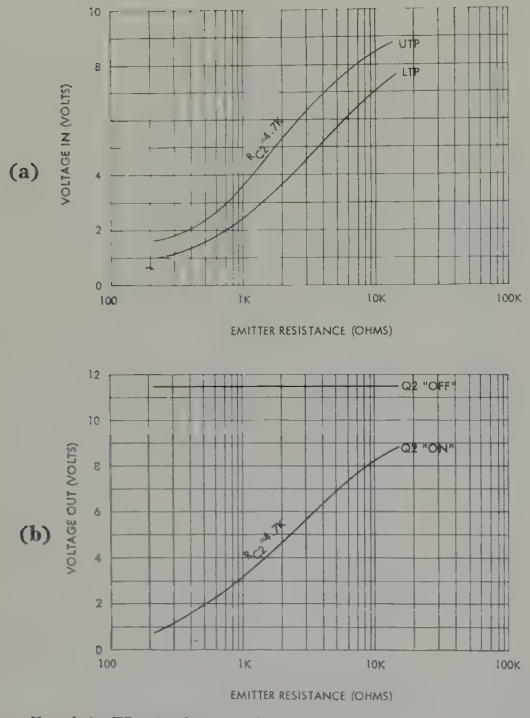


Fig. 5—(a) Variations of trip points for V_{in} versus R_E. (b) Output voltage versus emitter resistance.

another. For an upper trip point which is independent of the input waveshape, Q_2 should not be hard in saturation, since no regenerative action can be obtained until Q_2 comes out of saturation. A compromise must be reached here where stability vs. speed of response must be balanced to achieve the desired characteristics. The further Q_2 is in saturation (as opposed to the linear region of operation) the less drift and instability that will be incurred.

To effect a variation on the trip point, an input voltage divider such as a potentiometer could be used before coming into the input at R_B. This method does not change the circuit operation. A variable voltage bias could be inserted at the base or emitter of Q_1 through a suitable isolation resistance, or R_2 could be varied over some range of resistance. But each of these have certain disadvantages. Another method of providing a variable trip point adjustment over a wide range is to use a variable resistor in series with R_E; this can be seen from Equation 1. This has the effect of raising the emitter voltage without affecting the quiescent points of operation on the transistors as much as some of the other methods do. This has the disadvantage, of course, in that the output voltage swing is reduced with higher values of R_E.

Variations of R_E vs. trip points and output voltage are shown in Fig. 5 for the circuit in Fig. 3. A large value of R_E will tend to keep the collector current constant independent of small changes in transistor parameters. A large value of emitter resistance will also increase the input impedance, thus requiring less base drive current and making it more difficult to overdrive Q_1. Too large a value for R_E will result in Q_2 coming out of saturation, while too small a value for R_E will result in a poor "off" condition for Q_2.

(To be continued)

References

1. Millman and Taub, Pulse and Digital Circuits, 1 ed, McGraw-Hill, (1956).
2. Hunter, Handbook of semiconductor Electronics, 1 ed, McGraw-Hill, (1956).

APPLICATIONS ENGINEERING DIGESTS

APPLICATIONS ENGINEERING DIGEST NO. 75

Solid-State Square-Wave Oscillator Power Inverters; Minneapolis-Honeywell Regulator Co., Semiconductor Products Div., Minneapolis, Minn. (R. C. Swanson)

The circuit, as shown in *Fig. 75.1* fulfills all the requirements of a switching oscillator, which are as follows: (A) Transformer feedback coupling to produce phase reversal for positive feedback; (B) Loop gain greater than unity (when T_1 is not saturated); (C) Means of reducing the loop gain to less than unity (when T_1 is saturated); (D) Stored energy in inductive components to institute drive reversal.

The unique feature of this circuit is the small feedback transformer (T_1) which reduces the drive to the transistors as it saturates. This reduces the loop gain to less than unity.

If we consider Q_1 and Q_2 as switches, the operating principle of this circuit is quite easily understood. If Q_1 is biased *on*, i.e. conducting, as shown in *Fig. 75.2*, the supply voltage will be impressed across one-half (N_1) of the output-transformer primary, causing a constant

$d\phi/dt$. This can be seen in the basic formula:

$$E = -N \frac{d\phi}{dt} \qquad (1)$$

This $d\phi/dt$ will cause an induced voltage of approximately the same magnitude, to appear across N_2. Since Q_1 is saturated—with a collector-to-emitter voltage drop of less than 0.5 volt—the entire voltage developed on the primary (twice the supply voltage, see *Fig. 75.3*) will be seen collector-to-emitter on Q_2. Transistor Q_2 is biased off in this portion of the operating cycle.

When either Q_1 or Q_2 is conducting, there is a voltage impressed on the primary winding of the feedback transformer (T_1). This transformer is designed to saturate, after a given time, with the available supply voltage and current. As the core of T_1 saturates ($d\phi/dt \rightarrow 0$) it demands more magnetizing current.

This increased current causes an increased voltage drop across the feedback resistor (R_1), which, in turn, causes a decrease in the T_1 primary voltage. This decreases the drive power. As the magnetizing current increases further the drive becomes less and less until it no longer sustains the output load. The loop gain is then less than unity. As the induced voltages begin to collapse, all the polarities reverse, causing reversal of the oscillator. Therefore, Q_1 will be biased *off* and Q_2 biased *on*.

Designing the Power Supply

For a conservative design, the input voltage should not exceed one-half to three-fourths of the collector-to-emitter voltage rating of the transistor *in the active region.*

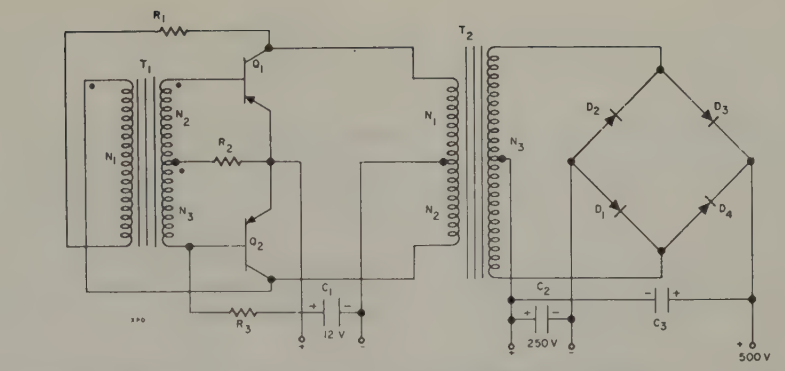
Knowing the output power, input voltage, and efficiency, the approximate current from the d-c source can be calculated. Since this current will pass through each side of the circuit on alternate half-cycles, it will determine the type of transistors (medium- or high-power), and the number of parallel transistors, if necessary, which must be used. Knowing the maximum collector current each transistor will carry, one can determine, from the data on the particular transistor being used, what drive will be necessary to drive the lowest gain unit well into saturation.

With this information, we are now ready to design the feedback transformer (T_1). The required drive power, the input voltage, and the operating frequency will determine the core size. Since this transformer is the one which saturates, the core must be square-loop material. A 1/4-inch stack of 6 mil. 1 DU orthonic or orthonol laminations is typical for lower-power units where the operating frequency is relatively high (800 cycles and above).

$$N_1 = \frac{E_1 \times 10^8}{4B_S A f} \qquad (2)$$

where:

B_s = saturation flux density in lines per sq. in.



T_1-Saturating Feedback Transformer
N_1-180T #27 } 20 Laminations
N_2 &N_3-50T #23 } of 1 DU 0.006" Orthonic
T_2-Output Transformer
N_1 &N_2-18T #13 Square } 1" stack
N_3-800T (CT) #28 } 1" EI steel

D_1-D_4 TI 1N2071 or equivalent
Q_1-Q_2 Honeywell DA3F3
R_1-20 ohm, 10 w
R_2-5 ohm, 10 w
R_3-47 ohm, 1 w

C_1-500 μf at 25v
C_2-C_3 8 μf at 450v

Fig. 75.1—125-watt power inverter.

A = cross section area in sq. in.

You will note that E_s, *(Fig. 75.2)* which denotes the input supply voltage, has been changed to E_1, which denotes the voltage impressed on the primary of T_1. E_1 is a square wave with an amplitude (peak value) of twice the supply voltage minus the drop across the feedback resistor R_1. This voltage drop across R_1 has been arbitrarily set at one-third of the available voltage. The remaining two-thirds would then appear across the primary of T_1. E_1 therefore would be 1-1/3 times the supply voltage (or 2/3 of $2E_s$).

The secondary windings are calculated using the formula:

$$N_2 = N_3 = N_1 \frac{E_2}{E_1} \qquad (3)$$

E_2 is determined by the required base-to-emitter drive voltage plus the voltage drop across resistor R_2. The drop across R_2 should be approximately one-third of the voltage developed across N_2 (or N_3). This resistor limits the base-drive current to a non-destructive value.

The value of the feedback resistor can be calculated if the current in the primary of T_1 and the voltage drop across R_1 (2/3 E_s) are known. This value is only approximate and may be varied to obtain the proper operating frequency.

Starting this circuit is difficult, or sometimes impossible, without the aid of a starting circuit. One of the transistors must be biased into conduction in order to cause an unbalance to start the cycle.

The circuit which is used to start the power supply in *Fig. 75.1* consists of R_3 and C_1. At the instant the supply is turned on, capacitor C_1 begins to take a charge which forward biases the base of Q_2. R_3 limits the capacitor charging rate. The value of C_1 should be between 100 and 500 μfd, depending upon the minimum mounting-base temperature and maximum load under which the supply is expected to start.

This type of circuit will work only if the input d-c supply is at full voltage as soon as the supply is turned on. If the supply being used starts at zero volts and slowly increases to maximum, a different type of starting circuit must be used. Remove capacitor C_1 and increase R_3 to 200-300 ohms. R_3 will then provide the forward bias for transistor Q_2. With $R_3 = 220$ ohms and an output of 97.5 watts, the supply would start at a minimum mounting-base temperature of −25° C.

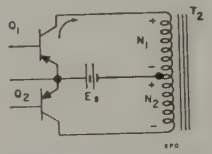


Fig. 75.2—Transistor Q_1 conducting.

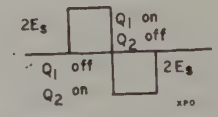


Fig. 75.3—Voltage seen between the collector and emitter of Q_2

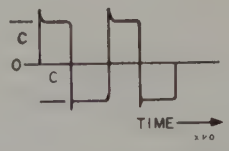


Fig. 75.4—Collector-to-collector waveform.

Proper Circuit Operation

When the circuit is turned on,

(Continued on page 50)

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Sept. 1, 1959 to Sept. 29, 1959. In subsequent issues, patents issued from Sept. 29, 1959 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

SEPTEMBER 1, 1959

2,902,547 Transistor Controlled Magnetic Amplifier—L. H. Rowley, H. Milenbach. Assignee: Sperry Rand Corp. In a magnetic amplifier transistor circuitry is employed to protect the signal source against excessive drain.

2,902,609 Transistor Counter—E. D. Ostroff, M. A. Meyer. Assignee: Laboratory for Electronics Inc. A magnetic core and a single transistor provide a bistable circuit which is independent of a wide range of transistor characteristics.

2,902,642 Testing Electrical Circuits For Ambiguity and Completeness— D. Voegtlen. Assignee: Siemens & Halske. A device for determining whether there is simultaneously more than one relay in operation, or whether there is simultaneously more than one potential supplied by a set of sources, in equipment which contains a plurality of such relays and sources, and in which proper operation requires actuation of only one such source or relay.

2,902,655 Transistor Oscillators—E. M. Jones, C. F. Winder. Assignee: The Baldwin Piano Co. A series L-C stabilized transistor oscillator which generates short pulses at equidistant intervals.

2,902,658 Apparatus For Generating Frequency Modulated Signals—D. C. Erdman. Assignee: Electrocircuits Inc. A circuit which can be used in ultrasonic equipment, and in which a sawtooth signal modulates the frequency of oscillation of a transistor oscillator over a predetermined range.

2,902,660 Electric Modulating Devices—E. Weisshaar. Assignee: Siemens-Scheickertwerke A. G. The Hall effect in InAs or InSb is employed to produce a modulator circuit.

2.902,674 Transistor Memory Circuit—T. E. Billings, C. Keshler, H. W. Wainwright. Assignee: General Electric Co. Means for maintaining the voltage on a storage device constant during a short readout period until a new voltage level is established.

SEPTEMBER 8, 1959

2,903,522 Transistor Anmplifier—R. A. Flower. Assignee: General Precision Laboratory Inc. In a negative feedback amplifier, a gain controlled stage in the feedback channel is used to vary the amount of negative feedback in proportion to the magnitude of the output signal.

2,903,601 Transistor-Magnetic Core Relay Complementing Flip Flop—S. Schneider. Assignee: Burroughs Corp. A pulse operated complementing flip-flop circuit not subject to time race, and operable at frequencies on the order of one magacycle.

2,903,602 Transistor Switching Circuits—H. Fleisher. Assignee: International Business Machines Corp. Logical circuits of the AND, OR and exclusive OR types.

2,903,603 Transistor Mono-Stable Sweep Generator—A. J. Glenn. Assignee: USA (Department of the Navy). A monostable multivibrator for use as a time base generator in a radar indicator.

2,903,604 Multistable Circuit—R. A. Henle. Assignee: International Business Machines Corp. A multistable counter circuit.

2,903,605 Extended Gate Generating Circuit—K. H. Barney, L. Greenspan. Assignee: Sperry Rand Corp. A timing circuit for generating a gating voltage in response to an input trigger pulse, the gating voltage being extended for a period of 10 to 15 seconds after the last received trigger pulse.

2,903,606 Logical Decision Circuitry for Digital Computation—D. L. Curtis. Assignee: Hughes Aircraft Co. Flip-Flop and gating circuit combinations which require little power and in which each flip-flop is capable of driving 300 different gating circuits.

2,903,607 Flip-Flop Resetting Circuit—F. G. Danner, G. C. Browne. Assignee: Sperry Rand Corp. Means for automatically setting the initial state of a bistable flip-flop at the time that the circuit is first activated.

2,903,608 Arrangement for Controlling a Transistor Circuit—H. U. Neidhardt. Assignee: H. A. Schlatter Aktiengesellschaft (Switzerland). In program scheduled electric welding apparatus, a system for modulating a transistor in a control circuit by means of mutually independent timing circuits.

2,903,628 Semiconductor Rectifier Devices —L. J. Giacoletto. Assignee: RCA. An ultra high frequency, low-loss semiconductor diode.

2,903,629 Encapsulated Semiconductor Assembly—N. K. Walker. Assignee: Advanced Research Associates, Inc. Method and apparatus for encapsulating a semiconductor device so that adequate means for heat transfer therefrom are provided.

2,903,630 Semiconductor Devices—R. M. Cohen, R. E. Rist. Assignee: RCA. Semiconductor devices having low total electrostatic feedback capacitance and low interelectrode capacitance.

2,903,631 Selenium Cells—L. F. Perotte. Assignee: General Electric Co. In cell formation, cadmium is sputtered on the cell to form a layer between the selenium and the counter electrode, which layer greatly improves the n-type characteristics of the cell.

2,903,632 Selenium Cells—L. F. Perotte. Assignee: General Electric Co. Photo voltaic selenium cells are produced with rubidium selenide and cesium selenide blocking layers.

2,903,636 Transistor Inverter and Rectifier Circuit—J. H. Guyton. Assignee: General Motors Corp. A full wave rectifier circuit which is transformer-coupled to a transistor oscillator and which is arranged to reduce the inverse voltage impressed across the transistor electrodes.

2,903.639 Current Supply Apparatus—G. W. Meszaros. Assignee: Bell Telephone Labs. A shunt transistor voltage regulator having a wide load current operating range.

2.903,640 Current Supply Apparatus—W. H. Bixby. Assignee: Power Equipment Co. A saturable reactor regulator is used to control the voltage supplied to a transistor regulator which is used in a circuit to reduce load voltage changes.

2,903,651 Spectrum Generator—A. Hahnel. Assignee: USA (Department of the Army). A periodically-phase-controlled type variable frequency oscillator which generates a plurality of harmonically related frequencies from a fundamental frequency input.

2,903,676 Binary Counter Transistor Circuit—B. Ostendorf, Jr. Assignee: Bell Telephone Labs. A binary counter array is arranged to control a number of individual intermediate output counting

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

branches while preventing interaction between the counter stages.

September 15, 1959

2,904,404 Preparation of Silicon—R. C. Ellis, Jr. Assignee: Raytheon Co. Apparatus for preparing silicon by reduction of the gas of a halogenated silane compound in a hydrogen-gas environment.

2,904,405 Recovery of Silicon from Silicon Dioxide—C. D. Thurmond. Assignee: BTL. Silicon dioxide is reduced in the presence of aluminum to form a mixture of silicon and aluminum oxide, and the mixture is then combined with molten tin which dissolves the silicon. The silicon-tin solution is treated to remove the tin and leave a silicon residue.

2,904,613 Large Area Solar Energy Converter and Method for Making the Same —M. E. Paradise. Assignee: Hoffman Electronics Corp. Crystallites of hyperpure semiconductor material are embedded in an insulating medium and supported on a reinforcing plate. The insulating layer is etched and plated in several steps and the device is assembled to form a large area solar cell.

2,904,641 Negative-Impedance Repeater Using a Transistor Amplifier—A. J. Radcliffe. Assignee: International Telephone and Telegraph Corp. A battery powered repeater used in a telephone transmission line.

2,904,645 Helmet Radios Including a Transistor Amplifier—G. A. Sarles. Assignee: None. A miniature receiver circuit suitable for personal contact call systems.

2,904,663 Apparatus for Zone Melting of Semiconductor Material—R. Emeis, J. Haus. Assignee: Siemens-Schuckertwerte, A. G. Apparatus for crucible-free zone melting of rod shaped semiconductor material.

2,904,678 Semi-Conductor Squelch Circuit —M. E. Malchow. Assignee: RCA. A noise suppression circuit wherein the input signal threshold does not vary with changes in supply voltage.

2,904,696 Electroluminescent Device and Networks—J. F. Elliott, R. E. Halsted. Assignee: General Electric Co. An amplification device comprised of an electroluminescent phosphor and a photoconductor arranged so that variations in phosphor light output cause corresponding variations in the impedance of the photoconductor.

2,904,697 Signal Translating Devices and Circuits—R. E. Halsted. Assignee: General Electric Co. Signal translating devices which accomplish their purpose through voltage modulation of photoluminescence.

2,904,704 Semiconductor Devices—J. C. Marinace. Assignee: General Electric Co. A device suitable for use at high frequencies.

2,904,705 Electronic Switch—G. Elliott. Assignee: General Dynamics Corp. A bistable triggered switching circuit which employs a double base semiconductor diode.

2,904,740 Circuit Arrangement for Converting Low Voltages into High Voltages —J. J. Rongen. Assignee: North American Philips Co. Inc. A low voltage to high voltage conversion arrangement wherein a low voltage is supplied to a transistor oscillator and the high voltage output thereof is rectified and filtered.

2,904,742 Current Supply Apparatus— F. H. Chase. Assignee: Bell Telephone Labs. A current supply circuit which controls load voltage changes over a normal range of load current.

2,904,755 Pulse Generating Circuit—M. P. Foley. Assignee: None. In a flasher circuit for a gas filled discharge tube, independent means for controlling both flash rate and flash intensity are provided.

September 22, 1959

2,905,771 Piezoresistive Semiconductor Microphone—F. P. Burns. Assignee: Bell Telephone Labs. A microphone which employs as its active element a body of indium antimonide which possesses an isotropic piezoelectric characteristic and therefore requires no specific crystallographic orientation.

2,905,815 Transistor, Operating in Collector Saturation Carrier-Storage Region, Converting Pulse Amplitude to Pulse Duration—H. C. Goodrich. Assignee: RCA. A circuit in which the duty cycle of the signal being processed may be altered in accordance with a control signal.

2,905,830 Light Amplifying Device—B. Kazan. Assignee: RCA. A panel type light amplifying and picture storage device capable of storing and reproducing half-tone shades.

2,905,835 Transistor Relay and Signal Shaping Device—P. G. Wray. Assignee: Teletype Corp. Transistor circuit means for reshaping signals having no sharp demarcation between impulses of different voltages into signals having this characteristic.

2,905,836 Semiconductor Devices and Systems—E. W. Herold. Assignee: RCA. Devices having reduced *alpha* fall-off effects and circuits therefor.

2,905,837 Detector Sampling Means—G. H. Barry. Assignee: Collins Radio Co. In a phase pulse system, means are provided for sampling the phase pulse detector outputs when their maximum signal to noise ratio has been achieved.

2,905,873 Semiconductor Power Devices and Method of Manufacture—J. Ollendorf, J. Bibby. Assignee: RCA. An alloy junction power transistor which may be etched or processed after subassembly of its heat dissipating structure.

2,905,904 Timing Control Circuit—W. E. Sargeant. Assignee: General Motors Corp. A controlled frequency timing impulse generating circuit.

2,905,906 Oscillator Frequency Control— E. Kittl. Assignee: None. Means for providing magnetic control of the frequency of a transistor oscillator.

September 29, 1959

2,906,002 Process for Producing Selenium Rectifier Plates—H. Nagorsen, H. Schweickert. Assignee: Siemens-Schuckertwerte A. G. (Germany). A process of cathode atomization and deposition is used to uniformly coat the selenium layer with an agent which promotes the formation of a blocking layer.

2,906,647 Method of Treating Semiconductor Devices—J. Roschen. Assignee: Philco Corp. Means for selectively plating the electrodes of a semiconductor device prior to soldering the leads thereto.

2,906,817 Television Receiver Signal Processing Circuits—M. C. Kidd, H. C. Goodrich. Assignee: RCA. A transistorized AGC system for television receivers.

2,906,888 Electrical Counting Circuits— F. H. Bray, R. G. Knight. Assignee: International Standard Electric Corp. A counting circuit, including a bistable crystal triode at each stage thereof.

2,906,889 Binary Trigger Circuit Employing Single Transistor—R. W. Emery, R. A. Henle. Assignee: IBM. A circuit in which means are provided for switching successive input pulses alternately to the emitter and to the base.

2,906,890 Electrical Circuits Employing Transistors—A. D. Odell, G. I. Turner. Assignee: International Standard Electric Corp. An information storage arrangement including bistable transistor circuits.

2,906,891 Transistor Pulse Transmission Circuits—J. J. Scanlon. Assignee: Bell Telephone Labs. Means are provided for eliminating the cumulative time delay in a circuit which transmits a d.c. pulse through a long chain of junction transistor gate circuits.

2,906,892 Shift Register Incorporating Delay Circuit—J. P. Jones, Jr. Assignee: Navigation Computer Corp. A phase discriminating electrical delay circuit for use with high speed shift register systems.

2,906,893 Transistor Blocking Oscillator— R. H. Mattson. Assignee: Bell Telephone Labs. Signal input means for transistor regenerative pulse amplifiers are described.

2,906,894 Binary Counter—J. R. Harris. Assignee: Bell Telephone Labs. A rapid acting reliable binary counter which responds to trigger pulses having variable duration.

2,906,930 Crystal Rectifier or Crystal Amplifier—K. E. Raithel. Assignee: International Standard Electric Corp. In junction devices, the metal or alloy which is diffused into the semiconductor to form the junction is also used as a means for attaching a terminal or connecting wire.

2,906,931 Semiconductor Devices—L. D. Armstrong. Assignee: RCA. A method for encapsulating semiconductor devices in a soft silicone material, and thereafter placing them in a hermetically sealed container.

2,906,932 Silicon Junction Diode—L. Fedotowsky, H. W. Marsh. Assignee: Sprague Electric Co. In a hermetically sealed silicon junction diode, aluminum alloy electrodes are coated with a protective material which prevents surface oxidation.

2,906,941 Current Supply Apparatus— S. J. Brolin. Assignee: Bell Telephone Labs. A regulating current supply circuit including a plurality of parallel connected variable impedance current paths.

(To be Continued)

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Mechanical Properties of Tellurium Single Crystals	Acta Metallurgica May 1961	The mechanical behavior of chemically polished tellurium single crystals has been determined for three orientations.	R. J. Stokes T. L. Johnston C. H. Li
Complex Conductivity of Some Plasmas and Semiconductors	Appd Science Res Sec. B, Vol. 9, No. 1	The complex conductivities of plasmas and semiconductors have been calculated for several cases where the collision frequency can be expressed as a power function of the energy.	P. H. Fang
An A-C Bridge for Semiconductor Resistivity Measurements Using a Four-Point Probe	Bell Syst Tech Jl May 1961	The use of a-c eliminates the influence of rectification, thermal, or contact potentials of the measurements.	M. A. Logan
A Loss and Phase Set for Measuring Transistor Parameters and Two-Port Networks Between 5 and 250 MC	Bell Syst Tech Jl May 1961	Set has been developed for making small-signal measurements with maximum inaccuracy of 0.1 db and 0.5 degree. Operation and applications are described.	D. Leed O. Kummer
Minimum Noise Figure of the Variable-Capacitance Amplifier	Bell Syst Tech Jl May 1961	Variable-capacitance diodes have a small series resistance which limits the minimum obtainable noise figure. This paper discusses the noise figure of parametric amplifiers taking this series resistance into account.	K. Kurokawa M. Uenohara
Scintillation Counters and Phosphors	May 1961 Brit Comm & Elecncs	Theory and operation of a scintillation counter. Various radiations are considered in conjunction with the theory of phosphors. Properties of five groups of phosphors are discussed.	D. R. Trotman
Use of Helium Flush in the Vacuum Deposition of Thin Films	Br Jl Appd Physics May 1961	Silver films deposited in a vacuum chamber previously flushed with helium exhibit less aggregation and reduced aging as compared with films produced under the usual procedures.	G. N. Srivastava G. D. Scott
The Physics of Computer Elements	Br Jl Appd Physics May 1961	Some interesting techniques employed in satisfying computing machine requirements are described together with the physical phenomena on which they depend.	C. N. W. Litting
Amplification Through Stimulated Emission-the Maser	Br Jl Appd Physics May 1961	Various factors which determine the ultimate sensitivity of a receiver are considered. The physical principles of emission and absorption of radiation are examined with particular reference to their application to microwaves.	R. A. Smith
Investigations on the Diffusion of Minority Carriers from a Point on Silicon	Canad Jl Physics May 1961	The field-free diffusion of minority carriers injected at a point in silicon has been studied, and the time, from injection to the maximum of the collector signal due to the arriving carriers, was measured for various emitter-collector distances.	C. H. Champness
A New Magnetic-Controlled Rectifier Power Amplifier with a Saturable Reactor Controlling on Time	Comm & Elecncs (AIEE) May 1961	This paper presents a technique for controlling the MA6-SCR by varying the time the SCR is turned on with the use of an insulated control winding to provide a desired characteristic.	R. E. Morgan
Commutation and Destruction Oscillation in Diode Circuits	Comm & Elecncs (AIEE) May 1961	The need for protective devices varies with a number of factors and phenomena. The investigation and testing of these phenomena and the study of how commutation may cause destruction of unprotected cells are discussed.	I. Somos
A Fatigue-Free Silicon Device Structure	Comm & Elecncs (AIEE) May 1961	A new hard-soldered structure is described which has been proved by long experience to eliminate fatigue failure.	W. B. Breen
A Comparison of Switching Devices, Electromechanical Versus Static	Elecl Des News May 1961	Comparisons are made of operate time, shock and vibration, life, ambient temperature, reliability, switching efficiency, contact arrangement, cost, weight and size.	J. Sylvester
A Transistor Multivibrator	Elecnc Engg (Br) May 1961	An emitter-coupled free-running multivibrator is described. The durations of quasi-stable states are controlled by the charging and discharging of a single timing capacitor.	B. Rakovick
Infrared Tracking Transducer Design	Elecnc Equip Engg May 1961	Solid-state detector provides coordinate voltages proportional to position of light spot on face of cell. Developmental models are capable of operation at 6-micron wavelengths.	J. S. Winslow D. P. Foote M. H. Jarsen
Charge Storage Techniques for High Speed Switching Circuits Part III	Elecnc Equip Engg May 1961	Discussion of flip-flop mulivibrator design. Curves are given indicating relationship between repetition rate, input trigger amplitude and supply voltage change.	J. F. Martin F. Niertit J. Shirman
Develop Practical Hall Effect Devices	Elecnc Industries May 1961	Design of a Hall effect isolator.	A. R. Hilbinger W. A. Scanga C. M. Barrack
Designing Solid State Commutators	Elecnc Industries May 1961	Practical design procedure includes circuitry and logic equations.	J. E. Toffler
Direct Coupling and D-C Stability	Elecnc Industries May 1961	Design of circuitry which is d-c stable with interchanging of transistors.	A. N. DeSautels
Basic RCTL Circuits	Elecnc Industries May 1961	A basic inverter circuit is discussed in detail. From it the NOR circuit and flip-flop are evolved. A Schmitt trigger using the basic circuit is also described.	W. D. Roehr
Tunnel Diode Curve Tracer is Stable in Negative-Resistance Region	Electronics May 5, 1961	Curve tracer described is capable of tracing the characteristics of tunnel diodes having a G_d^2/C_d ratio of up to 10^9 mhos^2 per pf.	J. A. Narud T. A. Fyfe
Three-Phase Static Inverters Power Space-Vehicle Equipment	Electronics May 5, 1961	Solid-state inverters develop 3-phase, 400-cycle, 115-volts a-c at 500 watts full load from an input of 22 to 29 volts d-c.	R. J. Kearns J. J. Rolfe
Cooling Transistors with Beryllia Heat Sinks	Electronics May 5, 1961	Article describes a series of tests run on beryllia heat sinks.	K. H. McPhee

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Monostable Pulse Generator Employs Zener-Diode Clamp	Electronics May 12, 1961	Description of circuit and operation; design equations presented.	C. M. Stewart
Step-by-Step Design Techniques for Multilayer Thin-Film Networks	Electronics May 19, 1961	Results of a study program are described. Six different circuit functions, encompasing a range of switching and communications applications were selected for fabrication and evaluation.	W. N. Carroll F. F. Jenny
Emitter Peaking Improves Video Amplifier Response	Electronics May 19, 1961	Analysis consists of calculation of equivalent input and output networks, and combination of these two calculations to provide useful design equations.	J. B. Fisher
Transformer and Shunt Transistors Regulate D-C Power Supply	Electronics May 19, 1961	Constant voltage transformer and shunt transistor regulator control of a d-c power supply. Feedback-sensitive circuit uses Zener diode as reference.	J. T. Keefe
Bandpass Transistor Amplifiers	Elecnc Technology May 1961	A determinant method is given for the analysis of the amplitude and phase responses of tuned amplifiers using transistors with complex internal feedback coupled by four- or two-terminal filter networks.	C. J. McCluskey
Organic Semiconductors	Electro-Technology May 1961	The phenomenon of conduction in organic polymers is reviewed in terms of semiconductor theory conductivity data for various compounds that have been investigated are cited. The future possibilities of practcial applications are explored.	H. A. Pol
Ultimate Sensitivity and Practical Performance of the Tellurium Photoconductive Detector	Infrared Physics Vol. 1, No. 1	Calculated and measured values indicate that the tellurium photoconductive detector is background limited, and therefore is ideal.	D. F. Edwards M. Mercado
A Status Report on Infrared Detectors	Infrared Physics Vol. 1, No. 1	Infrared photon detectors may be placed into two categories: intrinsic, and impurity activated detectors. Evaluation of the theoretical limit of detectivity indicates that most currently available single crystal detectors approach the theoretical limit to within a factor of two-three; average film detectors, however, differ by a greater amount.	P. Bratt
A Low Noise Microphone Preamplifier	IRE Trans Audio May-June 1961	In a transistorized preamplifier, a noise figure of 1.3, a mid frequency gain of 40 db, a bandwidth of 30 kc and an output impedance of 175 ohms has been achieved, for a source resistance of 1000 ohms.	A. B. Bereskin
Bridge Measurement of Tunnel Diode Parameters	IRE Tr Elecnc Devices May 1961	A specific bridge measurement technique is presented for measuring the important small signal parameter of the tunnel diode up to 100 mc, and at all significant operating levels.	W. H. Card
Four-Terminal Analysis of the Hall Generator	IRE Tr Elecnc Devices May 1961	The four terminal parameters of the Hall Generator are derived and then used to develop expression for input impedance, output impedance, current gain and voltage gain.	D. L. Endsley W. W. Grannemann L. L. Rosier
A Transistorized Tension and Loop Control	IRE Trans Ind Elecncs May 1961	Discussion of system design, components, and problems encountered in application.	T. E. DeViney
Transistorized Switching Control of a Variable-Speed D-C Motor	IRE Trans Ind Elecncs May 1961	Model was designed to control 20 amperes at 24 volts. Motor speed varies with the percentage of time the switch remains closed.	J. Allison P. Vergez
An Event Recorder Using Transistor Switches	IRE Trans Ind Elecncs May 1961	Conducting styli, writing on electrosensitive chart paper, are switched on or off by transistor circuits functioning as nonmechanical relays having fast response, high sensitivity, and reduced size.	J. W. Streater
Theory of TEM Diode Switching	IRE Tr Microwave T & T May 1961	This report covers a thorough investigation of the theory of TEM microwave diode switching and reports some modes of operating heretofore unreported.	R. V. Garver
Investigation of the Sputtering of Silicon	Jl Appl Phys May 1961	Sputtering yields for the argon silicon system over a range of ion energies from 34 to 800 ev have been determined. Data on ion bombardment of silicon with CO_2 is also presented.	S. P. Wolsky E. J. Zdanuk
Influence of Conductivity Gradients on Galvanomagnetic Effects in Semiconductors	Jl Appl Phys May 1961	An investigation of the influence of a macroscopic spatial variation of the magnetoconductivity tensor on the galvanomagnetic effects.	R. T. Bate A. C. Beer
Some Experiments Using a Vacuum Cleaned Silicon p-n Junction	Jl Appl Phys May 1961	Measurements are made of the transport properties and junction characteristics of a vacuum cleaned silicon p-n junction.	J. T. Law
Distribution Coefficients of Impurities in Gallium Antimonide	Jl Appl Phys May 1961	Distribution coefficients of several donor and acceptor impurities were measured during growth of GaSb crystals.	R. N. Hall J. H. Racette
Textural Properties of Germanium Films	Jl Appl Phys May 1961	Textural properties of thin Ge films which have been vacuum evaporated onto hot fused-quartz substrates have been investigated in the temperature range from 30°C to 650°C.	J. E. Davey
Third Order Elastic Moduli of Germanium	Jl Appl Phys May 1961	The six third-order elastic moduli in Ge have been determined by measuring ultrasonic velocities in selected directions when directed static stresses are applied to the crystal.	T. Bateman W. P. Mason H. J. McSkimin
Semiconducting Properties of Inorganic Amorphous Materials	Jl Appl Phys May 1961	Vitreous compositions prepared from the AsSeTe and AsSTe systems are studied. Resistivity, thermal conductivity and Seebeck coefficients were measured; Hall effect measurements are planned.	H. L. Uphoff J. H. Healy
Optical Studies of the Band Structure of InP	Jl Appl Phys May 1961	Reflectivity measurements of InP at several temperatures are reported.	M. Cardona
Some Electrical Properties of Zinc Telluride — Cadmium Sulphide Heterojunctions	Jl Appl Phys May 1961	Techniques of junction preparation and measurements and discussion of junction current-voltage characteristics are presented.	M. Aven D. M. Cook
The Design of Low-Noise Transistor Audio Amplifiers	Jl Audio Engg Soc Vol. 9, No. 2	Effect of various amplifier parameters on noise figure. Includes effect of operating point, biasing circuitry, and optimum source resistance.	J. W. Halligan
The Calculus of Deviations Applied to Transistor Circuit and Network Analysis	Jl Br Inst RE May 1961	The Calculus of Deviations is introduced, and its nature and basis are briefly defined. A deviation is described as "a measure of the lack of complete functional interdependence between two quantities".	T. R. Nisbet W. W. Happ

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Structures of Photoconductivity Spectra Near the Fundamental Absorption Edge of Cadmium Sulphide	Jl Phys Soc Japan May 1961	The photoconductivity structures of CdS single crystals near the absorption edge were investigated using polarized light at about 81°K.	H. Mitsuhaski
Photoconductive Hall Effect in Potassuum Bromide	Jl Phys Soc Japan May 1961	Discussion and results of a method employed to investigate the mobility of the conduction electron in KBr under space charge free conditions at temperatures between 80°K and room temperature.	M. Onuki
Interaction of Electrons and Holes with Acoustic Waves in Intrinsic Semiconductors	Jl Phys Soc Japan May 1961	A self-consistent theory is given for explaining the characteristics of the interaction of electrons and holes with acoustic waves in intrinsic semiconductors.	N. Mikoshiba
Etch Pits in Cadmium Sulphide Crystals	Philips Tech Rev Vol. 22, No. 8	A crystal was etched on the based plane and observed under a microscope using interference contrast.	A. J. Eland
Solid-State Research at Low Temperatures, III	Philips Tech Rev Vol. 22, No. 8	Thermal conduction in insulators, paramagnetism; dielectric losses related to chemical lattice imperfections.	J. Volger
The Scattering of Phonons by Bound Electrons in a Semiconductor	Philosoph Mag. May 1961	A carrier can jump from one impurity state to an unoccupied neighbor and thereby interact with lattice waves, thereby setting up a thermal resistance. The author calculates the effective mean free path of phonons affected by this mechanism.	I. C. Pyle
Large Dislocation Loops in Antimony Telluride	Philosoph Mag. May 1961	An explanation is given for the occurrence of pairs of concentric loops elongated in direction differing by 60°.	P. Delavignette S. Amelinckx
Photoconductivity and Trapping in Silicon Chloride Crystals	Physical Review May 1, 1961	The initial photoresponse increases with rising absorption constant, peaks at wavelengths for which the absorption constant is 3 to 5 cm^{-1} and falls rapidly to 1/20 to 1/10 of the peak value at wavelengths at which the absorption constant is 50 to 100 cm^{-1}.	A. M. Gordon
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Optical Constants of Germanium in the Region O-27 EV	Physical Review May 15, 1961	The reflectivity R has been measured for Ge crystal over the energy range 7.6 to 18.0 ev, and the transmissivity T for an evaporated Ge film over the range 16.6-27.4 ev.	O. P. Rustgi J. S. Nodvik G. L. Weissler
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Effect of Fission Spectrum Neutrons in n-type Germanium	Physical Review May 15, 1961	The electron removal rate for n-type germanium irradiated with fission spectrum neutrons is 8 ± 1 per neutron at room temperature. This value is compared with results of monoenergetic neutron irradiations from 2 to 5 mev.	D. Binder
The Effect of Pressure on the Absorption Edges of Some III-V, II-VI, and I-VII Compounds	Physical Review May 15, 1961	The effect of pressure of 160 kilobars was measured on AlSb, GaSb, InP, InAs, CdS, CdSe, CdTe, CuCl, CuBr, and CuI.	A. L. Edwards H. G. Drickamer
Storage Time of a Transistor with a Decaying Turn-Off Current	Proc IEE (BR) May 1961	A general expression is derived for storage time, under conditions of varying base current flowing during the storage time. Two examples are worked out.	D. M. Taub
Electrodeless Measurement of Semiconductor Resistivity at Microwave Frequencies	Proc IRE May 1961	The proposed technique depends upon the absorption of the microwave power being propogated through a semiconductor medium.	H. Jacobs
Fluctuation Noise in Semiconductor Space-Charge Regions	Proc IRE May 1961	Discussion includes equilibrium probability of ionization, noise effects, elemental event analysis, fluctuation analysis, and noise contributions vs temperature.	L. J. Gracoletto
A Matched Amplifier Using Two Cascaded Esaki Diodes	Proc IRE May 1961	Introduction of a new type of circuit for matched amplification using negative resistance devices. The circuit consists of a quarter-wave transmision line section whose input and output are paralleled by negative conductances.	D. R. Hamann
Low-Noise Amplifiers for Centimeter and Shorter Wavelengths.	Proc IRE May 1961	Discussion of the various techniques for attaining low noise, and a summary of the achievements relative to each technique.	G. Wade
Semiconductor Devices, Their Characteristics, Status and Future.	RCA Engr May 1961	Brief survey of semiconductor devices.	E. O. Johnson
Tunnel Diode Microwave Oscillators	RCA Engr May 1961	The use of tunnel diodes in u-h-f- and microwave oscillators with milliwatt power output. Describes diode performance parameters for oscillator circuits.	D. E. Nelson F. Sterzer
Induction Heated Pressure Vessel for Growing Oxide Single Crystals	Review of Scient Instmnts May 1961	An induction-heated oxygen-pressure vessel was constructed to grow ferrite crystals under sufficient oxygen pressure to minimize their decomposition. Furnace is capable of operation at 1600°C and 75 atm pressure.	A. Ferretti D. G. Wickham A. Wold
Transmission-Type Piezoelectricity Detector (Note)	Review of Scient Instmnts May 1961	A differential transmission circuit using diodes is employed to subtract out most of the noise originating in the r-f source.	R. J. Blume
Chuck Design for Holding a Silicon Rod in Floating Zone Crystal Growing (Note)	Review of Scient Instmnts May 1961	Description of chuck which has been found satisfactory for both experimental and production operations.	N. Hemmat A. L. MacDonald
Zener Diode Circuits for Stable Transistor Biasing (Part 1)	Semiconductor Prods May 1961	Design methods and experimental results with Ge and Si units are given for the Zener diode scheme and compared to conventional methods of biasing.	J. Kubell V. H. Grinich
Exact Calculations for Class A and B Transformer Coupled Amplifiers	Semiconductor Prods May 1961	Simple design procedures have been detailed for class A and B designs which allow very good prediction of circuit performance.	J. S. MacDougall

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Transistor Response of Grounded Emitter Switching Circuits	Semiconductor Prods May 1961	The transient response of a non-saturated grounded emitter switch is analyzed in this article. The effect of collector capacitance and load resistance is taken into effect.	S. C. Chao
The Evaluation of "Esaki Integrals" and an Approximate Expression for the Tunnel Diode Characteristic	Solid State Elecncs Vol. 2, No. 4	A simple analytical current vs. voltage characteristic for the tunnel diode has been obtained which has approximately the same degree of validity as Esaki's original theory.	T. P. Brody R. H. Boyer
A Low-Resistance Ohmic Contact for Silicon Semiconductor Devices	Solid State Elecncs Vol. 2, No. 4	A low-resistance ohmic contact to lapped silicon can be obtained by a displacement plating of gold followed by an electrodeposition of copper.	S. L. Matlow E. L. Ralph
Direct Recombination in GaAs and Some Consequences in Transistor Design	Solid State Elecncs Vol. 2, No. 4	Experiments are presented that the semiconduction rate R in GaAs is given by the expression $R = Bpn$ where b is a constant and p and n are the hole and electron densities respectively.	S. Mayburg
Alpha Cutoff Frequency of Junction Transistors	Solid State Elecncs Vol. 2, No. 4	The alpha cutoff frequencies of drift and diffusion transistors are analyzed and approximated by simple expressions.	J. Lindmayer C. Wigley
Injection Electroluminescence	Solid State Elecncs Vol. 2, No. 4	It is shown that the theoretical limit for brightness and efficiency of injection EL can be expected to be higher than that of impact ionization EL.	A. G. Fischer
The Potentialities of Silicon and Gallium Arsenide Solar Batteries	Solid State Elecncs Vol. 2, No. 4	The theory of spectral response of a p-n junction solar battery is given. and detailed comparisons are made of the expected performance of silicon and gallium arsenite units.	T. S. Moss
Molten-Diffused Silicon Transistors	Solid State Elecncs Vol. 2, No. 4	Production of transistors using the molten diffused process. Base widths less than 1μ and cut-off frequencies in the order of 580 Mc/s are obtained.	S. Tauchi
Power Generation and Heat Producing Thermoelectric Phenomena	Solid State J1 May 1961	Review article covers backgrounds, present devices, and prospects for future.	H. Mette
Semiconductor Diode Strings Under Voltage Transients. Part 2	Solid State J1 May 1961	Discussion of ranges validity, and low, medium, and high frequency range design. Example of one complete design.	E. J. Diebold
The Annealing of Defects Formed In N-Germanium by Gamma Rays	Sov Phys Solid State April 1961	Non equilibrium carrier lifetime is assumed to be inversely proportional to defect density. The dependence of carrier lifetime upon temperature and duration of the anneal is investigated.	N. S. Zhdanovich F. F. Konopleva S. M. Ryvkin
Concerning The Theory of Photomagnetoelectric Effects In Semiconductors With Complex Energy Bands.	Sov Phys Solid State April 1961	A discussion of the anistropic PME effect in semiconductors is given.	Y. I. Ravich
The Kinetics of Impurity Photoconductivity and Effective Cross Sections of Local Centers.	Sov Phys Solid State April 1961	An analysis is given of the impurity photoconductivity kinetics corresponding to the creation of nonequilibrium charge carriers in the majority conduction band only.	E. I. Adirovich
Electrical Transport of Gold in Silicon	Sov Phys Solid State April 1961	A study of electrical transport, diffusion, and solubility of gold in silicon.	B. I. Botako B. S. Kulikov R. S. Malkovich
The True Lifetime and a Possible Mechanism of the Non-elastic Scattering of the Current Carriers in Semiconductors	Sov Phys Solid State	Minority carrier lifetime, impurity and intrinsic photoconductivity and a mechanism therefor are considered theoretically.	S. M. Ryvkin
The Energy Distribution of Surface Electron States For A Pure Germanium Surface With and Without The Presence of Adsorbed Oxygen	Sov Phys Solid State April 1961	The effect adsorbed gases upon surface electron states is investigated.	V. I. Lvashenko N. S. Chernaya A. B. Gerasimov
The Applicability of a Steady State Photoconductivity Method To Investigation of the Dependence of Surface Recombination Velocity on The Surface Potential	Sov Phys Solid State April 1961	This rapid method involves measurements of steady state photoconductivity and large signal field effects over the entire range of surface potential variation.	A. V. Rzhanov
Certain Features of The Dependence of the Forbidden Band Width and the Carrier Mobility on the Composition of Te-Se and Te-S Solid Solutions	Sov Phys Solid State April 1961	Composition dependence of the forbidden bandwidth when low concentrations of sulfur and selenium are present is discussed.	V. N. Lange A. R. Regel
The Nernst-Ettinghausen Effect In P-Type Gallium Arsenide	Sov Phys Solid State April 1961	The NE effect was studied at temperatures up to 800°K in a magnetic field of 7000 oersteds. A conclusion drawn from results is that acoustic lattice vibrations are closely associated with hole scattering at high temperatures.	O. V. Emel'yanenk D. N. Nasledov R. V. Petrov
The Temperature Dependence Of The Chemical Potential In A Semiconductor	Sov Phys Solid State April 1961	In the calculation of the temperature dependence of the chemical potential of a semiconductor, the temperature dependence of the forbidden band width must be considered.	S. I. Chanyshev V. E. Zgaavskii
The Mechanism of Negative Photoconductivity	Sov Phys Solid State April 1961	Negative photoconductivity in a polycrystalline layer is attributed to the recombination of photoelectrons with the surface states in n-type semiconductors.	G. Grossmann S. M. Ariya
Films of Semiconducting ZrO_2	Sov Phys Solid State April 1961	Semiconducting films of ZrO_2 are produced by introducing Sn and Bi impurity atoms into the ZrO_2 lattice.	A. Y. Kuzentsov L. A. Pafomova
Semiconducting Apparatus with Negative Resistance	Telecommunications (Trans. USSR) Vol. 1, No. 2	An attempt is made to establish the optimal form of the volt-ampere characteristic in relation to the purpose of the apparatus.	M. A. Berg J. A. Garyainov
Calculation of Video Amplifiers with Transistors	Telecommunications (Trans. USSR) Vol. 1, No. 2	The necessary calculation relations for three types of semiconductor video stages (common emitter, common collector, and common base) are given.	A. A. Rizkin
A-C to D-C Power Conversion with Silicon Rectifiers	Westinghouse Engr May 1961	Compact silicon power rectifiers up to 170 KW offer dependable and economical power conversion in a variety of applications.	E. J. Laughlin

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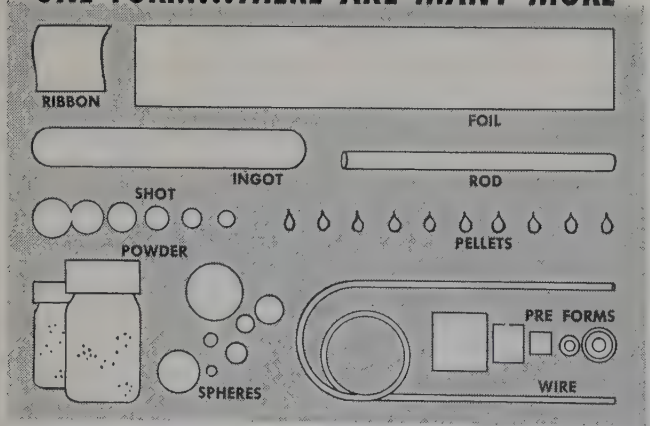

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Market News

Sales

Japanese exports to the United States, according to the Finance Ministry, for the first six months of this year has shown major gains over the same period last year. Transistors totaled almost 3.2 million units against 832,000 units during the same period last year, while other semiconductors totaled about 1.5 million units against 58,000 units.

Raytheon Co., has formed a subsidiary to market its transistors, diodes, rectifiers, tubes and other components in Europe. The new firm, Raytheon—Elsi AG will have its headquarters in Zug, Switzerland.

Electronic Devices, Inc., New Rochelle, N.Y., manufacturers of selenium and silicon semiconductor devices has appointed Westchester Electronics as distributor in Putnam and Rockland Counties N.Y., and Fairfield County, Conn. The firm has also appointed Cartwright and Bean, Memphis, Tenn., and Atlanta, Ga., as their manufacturer's representative to handle sales in that area.

General Instrument Semiconductor Division has established two new sales regions and a new district sales office, and has appointed three new district sales managers and six additional sales engineers. The two new sales regions are a Northeast Region, comprising upper New York state and New England, and a Southeast Region, from mid-New Jersey to Florida. The new district sales office is in Dayton, Ohio.

Alpha Metals, Inc., has appointed a technical representative for the New England states of Massachusetts, Vermont, New Hampshire, Rhode Island and Connecticut.

Suppliers

Sprague Electric Co., Concord, N.H., has introduced six new silicon transistors for use in low-level chopper applications. These types, 2N2162 through 2N2167, are packaged in the TO-5 case and vary in price from $13.55 to $10.15 each in quantities less than 100. In lots over 100 prices range from $9.95 to $7.45 each.

The Special Products Operation of Philco Corp's Lansdale division is now marketing a three-device line of Germanium varactor diodes designed as harmonic generators. In quantities less than 100, type L-4110 is listed at $120 each; L-4111 at $80, and L-4112 at $120. The company has also made available a new line of silicon photosensors designed for photo diode readout circuitry in data processing equipment. Sample quantities are available at prices ranging from $5 to $12 each depending upon customer specifications.

The Semiconductor Products Department of General Electric Co., Syracuse, N.Y. is reentering the semiconductor diode field after having dropped out in 1954. GE is now producing germanium and gallium arsenide tunnel diodes and back diodes as well as silicon planar epitaxial, passivated high speed switching signal diodes. The silicon unit designated SD150 is priced at $5.50 each in quantities less than 1000. It is also available in a microminiature package at $8.90 each.

Advanced Vacuum Products, Inc., Stamford, Conn., a subsidiary of Glass-Tite Industries, Inc., plans to extend its position in the semiconductor industry by marketing new ceramic-to-metal devices. The firm's new products include transistor headers, pin seals, tunnel diode bases, printed transistor bases, heat sinks and diode closures.

Financial

Sprague Electric Co., has purchased all of the CBS Electronics transistor production equipment for use in its plant located in Concord, N.H.

Philco Corp., and the Ford Motor Company have jointly announced the purchase of Philco by Ford. The auto firm plans to obtain the more than 1 million common shares needed to complete the transaction from a portfolio of over 29 million class A non-voting shares held by the Ford Foundation.

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Layfayette Radio & Electronics Corp. has reported net earnings of $790,028 equivalent to 77¢ a share for the fiscal year ending June 1961. This is compared to $565,655 or 55¢ a share earned in the previous fiscal year. Net sales rose to $23,565,861 from $18,128,306.

Newark Electronics Corp., parts distributor in Chicago, has acquired Industrial Electronic Supply, Inc., Grand Rapids, Mich., for an undisclosed amount of stock.

Allied Chemical's sales reached new highs in May and June 1961, slightly above the record levels previously reached in the corresponding 1960 months. Earnings in May and June closely approximated year ago results and for the second quarter amounted to $.81 per share, 7% below the all-time record $.87 for the 1960 quarter. Sales of $211.3 million in the second quarter of 1961 were off about 2½% from those of the 1960 quarter. With the marked improvement in the second quarter, earnings in the first half totaled $1.28 a share or 17% below the $1.55 record first half of 1960. First six months' sales of $379.9 million were 5% below the previous year's corresponding period.

Merck & Co., Inc. reported a slight increase in sales but a 16 per cent decrease in net income for the first six months of 1961 compared with the corresponding period of 1960. Consolidated net sales for the first six months of 1961 were $112,786,000, compared with $111,416,000 for the first half of 1960. Estimated net income for the 1961 period was $12,369,000 or $1.14 per share of common stock, compared with $14,784,000 or $1.37 per share for the first six months of last year.

Alloys Unlimited, Inc. has acquired the Ceramics for Industry Corporation, formerly the R & D Division of Sylvania Electric Products. CFI became a division of Alloys Unlimited through a stock exchange agreement. The purchase price was approximately 30,000 shares of Alloys Unlimited common stock. The CFI plant, occupying 15,000 square feet of space, is located in Mineola, N. Y. With complete production and engineering facilities, CFI offers a comprehensive integrated service for the fabrication of both ceramic parts and ceramic-to-metal composites.

New THERMO-PROBE

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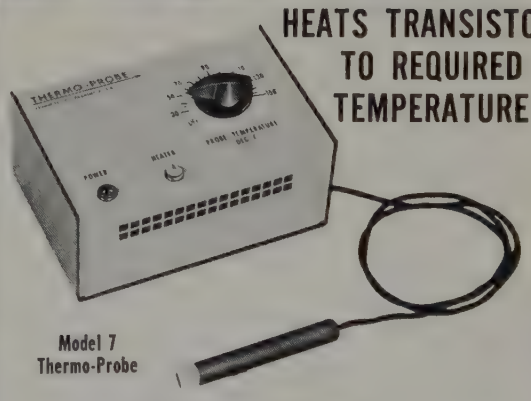

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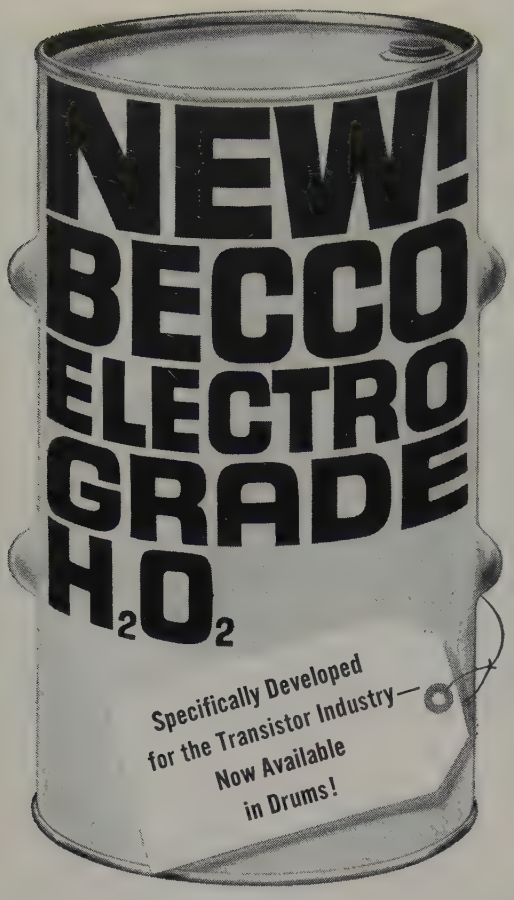

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Texas Instruments Incorporated reported to its stockholders that sales billed for both the six-month and three-month periods ended June 30, 1961 were higher than for comparable periods of 1960, but net earnings were lower. Sales for the first six months of 1961 were $119,860,000 and net earnings were $6,374,000, equal to $1.60 per common share. For the first six months of 1960, sales were $116,051,000 and net earnings were $7,921,000, equal to $2.00 per common share. For the three-month period ended June 30, 1961, sales billed were $60,883,000 and net earnings were $2,601,000, equal to $0.65 per common share on 3,935,494 shares outstanding. For the three-month period ended June 30, 1960, sales billed were $59,853,000 and net earnings were $3,991,000, equal to $1.01 per common share on 3,923,687 common shares then outstanding.

Directors of Allied Radio Corporation have declared the regular quarterly dividend of 8 cents a share on the company's common stock. This action brought the total of dividends declared in the current fiscal year to 32 cents a share.

Glass-Tite Industries, Inc., Providence, R. I., has reported a net profit of $201,600 for the first six months of 1961. This was 61% up from the $123,165 for the first half of 1960. Sales were $2,883,000 for the six months ending June 30 as against $1,729,336 for the same period last year.

BTU Engineering of Waltham, Massachusetts, manufacturer of high temperature furnaces for the semiconductor and electronic industries, reports record sales for the fiscal year 1961 of $1,239,036 and a net income of $130,033, or $0.22 per share. This represents an increase of 49% in sales and an increase of 22% in earnings over 1960.

Expansion

Raytheon Co.'s Semiconductor division is consolidating its Massachusetts silicon transistor, rectifier and transistorized circuit module activities in the 200,000 square foot building in Lowell, Mass., recently purchased from CBS.

The technical service laboratory of Allied Chemical's General Chemical Division has been moved to new quarters at the Company's Morris Township, New Jersey research center. The new technical service facilities occupy part of a recently completed laboratory wing. Previous site was in Edgewater, New Jersey.

Monsanto Chemical Company, St. Louis has established an applied mathematics department within its Research & Engineering Division.

Penfield Manufacturing Company, Inc., Meriden, Conn., pioneers in "packaged" industrial demineralization for the process and electronic industries, will move this Fall to newly acquired facilities at 57 Britannia Street. Existing buildings at the new site will double the company's production floor space and provide for expanded design, engineering and laboratory facilities.

Cominco Products, Inc., Spokane, Wash., is establishing a new ultra modern plant in the Spokane Industrial Park to produce high purity metal products for the electronics industry. The plant is scheduled to commence operations early in March.

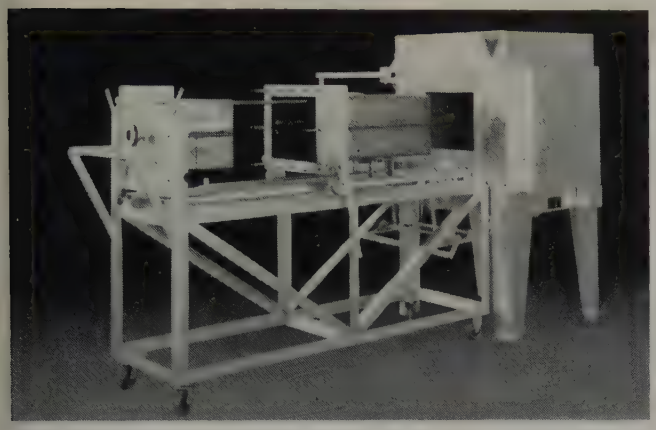
Allied Radio Corporation has announced the formation of a new corporate subsidiary, Allied Electronics Corporation, to direct intensified activity in the industrial electronics field. The new subsidiary will assume the sales role formerly handled by the parent company's industrial division.

Sigmund Cohn Corp. has recently organized the Sigmund Cohn Corp. of California, 151 C. North Maple Street, Burbank, California to handle the various lines of wire, sheet and other products of Sigmund Cohn Corp. and its affiliates, Sigmund Cohn Mfg. Co., Inc. and Pyrofuze Corp. These products are all manufactured in the Corporation's plant at Mount Vernon, N.Y.

New Firms

Herbert Miller has organized Clark Semiconductor Corp., Clark, New Jersey to produce very high frequency power semiconductor devices. The company will specialize in the manufacture of triple diffused silicon mesa transistors in the frequency range of 200Mc and higher with outputs of 3 watts and above. The company's new plant is completely air conditioned, has a pressurized white room to assure a dust-free environment for maintaining high production standards and is fully outfitted with the newest manufacturing and inspection equipment. Mr. Miller states that the most advanced techniques will be employed and 100% testing will be applied to all products.

New Removable Muffle Converts General-Purpose Electric Furnace for RETORT HEATING



With this new Pereco Loading Accessory closely controlled protective atmosphere work can be performed in a standard Pereco 2400° F General-Purpose Heat Treating Furnace. Quickly removable muffle reduces cooling time and speeds up heating cycle. Use of two or more racks permits continuous furnace operation. Spring-loaded, plug-type door provides explosion protection. Among still other advantages, use of this conversion unit permits almost instantaneous conversion from retort to conventional operations.

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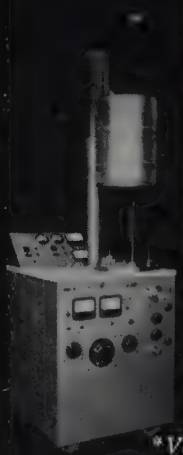
. . . When it comes to disappearing acts, Vactronic's new portable High Vacuum Evaporator performs the most effective one yet seen . . . does it speedily and accurately, evaporating every kind of metal now being used, to aid in the development of new semiconductor mediums. No slipshod slight-of-hand artist this — but a polished, proven performer . . . capable of conjuring up thin film configurations to help you create various semiconductors or microminiaturized circuits. Featuring a guaranteed ultimate better than 2×10^{-7} mm. of Hg., the Vactronic Portable High Vacuum Evaporator, Model HVE-450 needs neither screw driver nor magic wand to assemble . . . comes complete, ready to operate. But don't waste time on incantations . . . send for complete details today.



**Vactronic's HVE-450*
High Vacuum Evaporator

Vactronic

LAB. EQUIPMENT, INC.

East Northport, Long Island, New York

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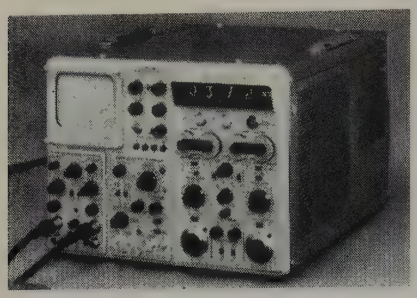
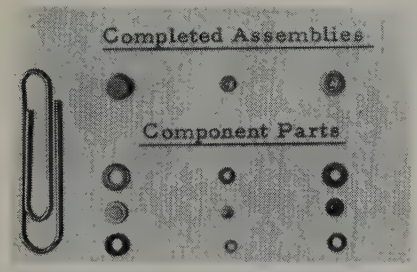
Readout Oscilloscope



Adding readout convenience to dual-trace applications, the Tektronix Type 567 Oscilloscope presents simultaneously an analog display on its 5-inch CRT with a digital presentation on the automatic computing programmer. In a typical application such as transistor-switching-time measurement, you can read directly such characteristics as the delay, rise, storage, and fall time; the total turn-on and turn-off times; the width of pulse A and B; and time and amplitude between two selected points on either or both waveforms.

Circle 113 on Reader Service Card

Ceramic-To-Metal Housings



Miniature ceramic-to-metal seal assemblies for housing tunnel diodes are now in production at Advanced Vacuum Products. ADVAC Tunnel Diode Housings are made from aluminum oxide rings, moly manganese metallized and furnace brazed to Kovar metal washers and caps. The housings are as small as .090 in diameter, and .030 in overall height. They have high mechanical strength, as much as 15-20,000 p.s.i. tension. The housings are constructed to withstand temperatures in excess of 1500°F.

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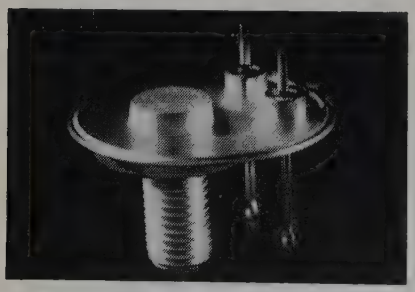
Semiconductor Base Assemblies



An expanded line of brazed semiconductor base assemblies is available from Standard Pressed Steel Co. The new finished bases come with virtually all brazing and plating operations completed. Pre-assembly includes the joining of such parts as glass-sealed pin terminals, weld ring, base plate and threaded copper heat sink. And also special molybdenum or silver-tungsten pedestal discs with suitable protective coating, if the coefficient of expansion of the semiconductor wafer is incompatible with that of copper pedestal.

Circle 133 on Reader Service Card

Improved Temperature Control

Delta Design, Inc. has announced that their 1060 Series temperature chambers, which pioneered the $\pm\frac{1}{2}$°F control in portable temperature test units are now being routinely built and specified at $\pm\frac{1}{4}$°F control accuracy. The new chambers use the same simple, reliable d'Arsenval pendulum proportioning control system which has a theoretical resolution limit of zero. The upgrading has been achieved by systematic quality control and design refinements.

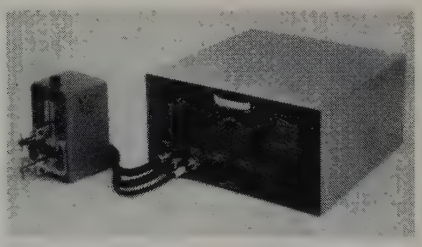
Circle 104 on Reader Service Card

Thermoelectrically Cooled Infrared Detector

Radiation Electronics offers an efficient, low current thermoelectric (Peltier) cooler which has been coupled to a photoconductive indium antimonide (InSb) element to provide high detectivity in the 1 to 6 micron spectral region without complex gas or liquid cooling systems. Except for a small infrared window, all metal construction is used in the compact detector-cooler package. A three-stage Peltier cooler, which requires $2\frac{1}{2}$ amperes at 2 volts, reduces the detector temperature to approximately the dry ice point. Operating Temperature: approximately —78°C(195°K).

Circle 132 on Reader Service Card

Dual-Range Electronic Welder



Weldmatic Division/Unitek Model 1059 is a solid-state, capacitor-discharge welder power supply with full circuit switching for each of two ranges. It is essentially two power supplies in one. Maximum versatility in this voltage regulated unit is achieved by rapidly switching from a low range of .04 to 9 watt-seconds to a high range of .2 to 45 watt-seconds, as required. Typical applications include fine whisker-wire attachment to semiconductor leads, microcomponent lead attachment in deposited thin-film circuitry in the low range, and connecting component leads to circuit ribbon in high-density packaging in the high range. Output energy is maintained within $\pm 1\%$ for voltage regulated input variation between 100 and 130 volts a-c. Discharge time is approximately .001 second.

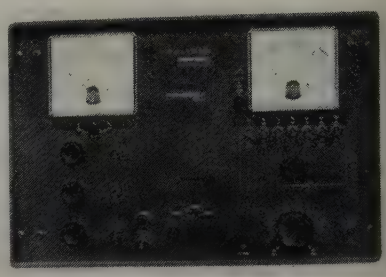
Circle 118 on Reader Service Card

Insulating Coating

A new single-component insulating coating specially designed for high temperature applications is announced by Columbia Technical Corporation. Humi-Seal Type 1C40, is recommended for continuous operation up to 300°C. It is abrasion resistant, has very good general weathering resistance, and excellent adhesion. Made to meet Fungus Proof Specs. MIL-E-005272B, it also has excellent resistance to chemical solvents.

Circle 119 on Reader Service Card

Test Set



Dynatran Electronics Corporation announces its new Model 1803A Transistor Parameter Test Set. This instrument measures all the small signal parameters for both n-p-n and p-n-p transistors, in both the grounded emitter and grounded base connections with an accuracy of 3%. The instrument is biased in the grounded base connection for all measurements by means of two easily set regulated supplies. Collector leakage current can be read over a wide range of values from less than one nanoampere to one milliampere.

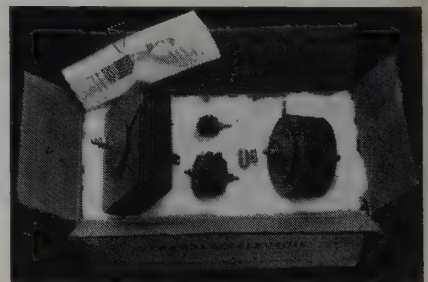
Circle 130 on Reader Service Card

Gold-Tin Eutectic

Accurate Specialties is now producing precision preforms from gold-tin eutectic. Acculoy 280C is described as a truly homogenous Au80-Sn20 alloy with atomically interspersed elements. With a 280°C melting point, it wets and forms alloys with many metals and other alloys, the company reports. The alloy is supplied in precision squares, rectangles, discs and washers up to 1.5" diameter, in thicknesses from .001" to .015" finished gauge. It is also available clad to nickel, nickel-iron alloys, and nickel-iron-cobalt alloys.

Circle 115 on Reader Service Card

Thyrector Diodes



A complete line of selenium Thyrector Diodes which control damaging voltage transients in semiconductor circuits has been introduced by the General Electric Company. The six cell sizes range from 9/32 and 15/32 inch diameter disks for mounting in tubes and 1x1 inch, 2x2 inch and 5x6 inch plates and $4\frac{3}{8}$ inch disks for stud mounting. The 9/32 and 15/32 inch diameter cells have a steady state cell rating of 30 volts RMS. The 1x1, 2x2, and 5x6 plates and $4\frac{3}{8}$ inch diameter cells have a steady state rating of 25 volts RMS.

Circle 111 on Reader Service Card

Products

Microwave Mixer Diode

A new high burnout X-band silicon microwave mixer diode which will withstand more than twice the spike energy of its closest counterpart has been announced by Sylvania Electric Products Inc. Type D4181 is identical mechanically and electrically to Type 1N23C which it replaces directly in applications involving high incident RF energy. However, with a spike energy rating of five ergs, it is far more rugged than its two-erg counterpart, according to the company.

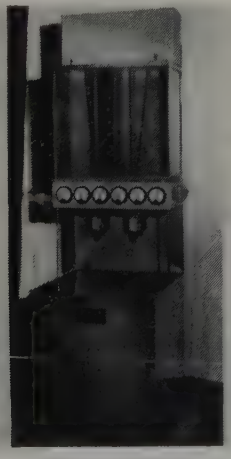
Circle 109 on Reader Service Card

Chopper Transistors

Philco's Lansdale Division has introduced new silicon precision alloy transistors (SPAT) capable of operating at collector (V_{CEO}) and emitter (V_{EBO}) voltages of 30 volts each with leakage current of only 15 nanoamps maximum at 65°C. The T-2363 and the matched pair T-2357 are specifically designed for application in high-accuracy electronic choppers, multiplexes, demodulators, and other high resolution low level switching circuits.

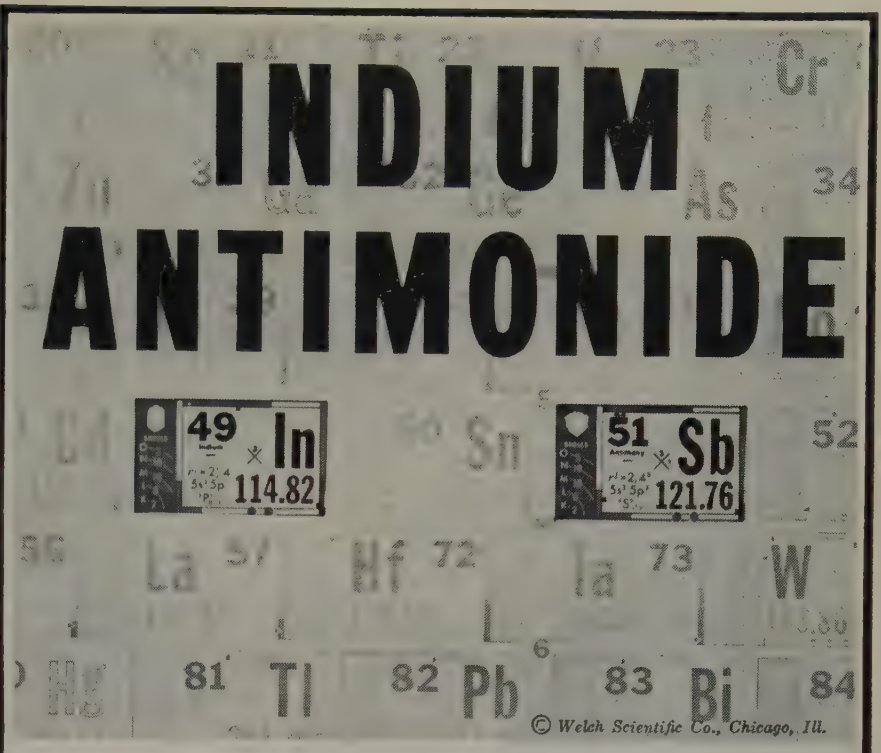
Circle 107 on Reader Service Card

Automatic Dispenser



Penfield Manufacturing Co., Inc., announces the development of an automatic dispenser, Model PD-1000, for drawing off precisely measured quantities of liquid solutions, featuring push button operated, timer controlled draw-off stations and a dual constant pressure, continuously agitated storage system. Any desired number of controlling timers may be incorporated in the unit, the dial settings of which will enable drawing off, fully automatically, through solenoid actuated non-drip valves, required precise quantities in the 25 to 1,000 cc range.

Circle 116 on Reader Service Card



YOU CAN SPECIFY

—Electron Mobilities up to 800,000 cm^2/volt-sec (78°K).
—Net Carrier Concentrations from 10^{14} to 10^{18} cm^{-3} (78°K).
—Single and Polycrystalline forms doped to your specifications.
—Circles, rings, rectangles and bars—made to precise tolerances.

SPECIAL PACKAGING

To prevent in-transit damage to electronic properties, your order of **Indium Antimonide** will be sealed in polyethylene and shipped in shock-proof containers. Fabricated shapes are suspended in an inert liquid.

RESEARCH SERVICE

Our research and development program is continually expanding the range of **Indium Antimonide** products you can order. We invite your enquiries on advance specifications.

Contact us first for the widest range of high quality **Indium Antimonide** products available.

COMINCO PRODUCTS, INC.

ELECTRONIC MATERIALS DEPARTMENT

933 W. Third Ave., Spokane, Washington

Phone: RIverside 7-7103 TWX: SP311

ULTRA-PURE METALS AND ALLOYS: Aluminum • Antimony • Arsenic • Bismuth • Cadmium Gold • Indium • Lead • Silver • Tin • Zinc. **STANDARD FORMS:** Ingots • Bars • Rods • Ribbon • Sheet • Shot • Powder • Wire. **PREFORMS:** Discs • Dots • Squares • Spheres • Wafers • Washers. **COMPOUND SEMICONDUCTORS:** Indium Antimonide. **CHEMICALS:** Salts • Solutions.

Circle No. 30 on Reader Service Card

FULLY INSTRUMENTED, SELF CONTAINED, MOBILE POWER SUPPLY FOR USE WITH ELECTRON BEAM CUTTING AND WELDING EQUIPMENT

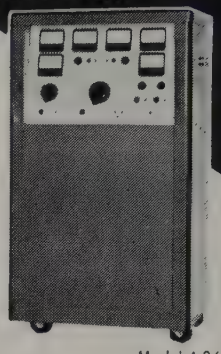
Input 220 V, 3 Ø, 60 cycle line

HIGH VOLTAGE SUPPLY — 6 KW
- Overvoltage and overcurrent electronic tripping device — front panel control adjustable from 0 to full range
- Full control 0 to max. output voltage
- Surge protection for fast transients
- 10% no-load to full-load regulation
- Zero-start interlock
- 4% R.M.S. ripple

FILAMENT TRANSFORMER SUPPLY — 1 KW
- Output insulated for full high voltage from ground
- Full control from 0 to max. output current
- Filament meters

BIAS SUPPLY — 10 WATTS
- Output insulated for full high voltage from ground
- Full control from 0 to max. output voltage
- Meter for output voltage
- Surge current protection
- 1% R.M.S./MA ripple

ELECTRON BEAM POWER SUPPLY



Model A 2632

OTHER RATINGS AVAILABLE — Write for Data

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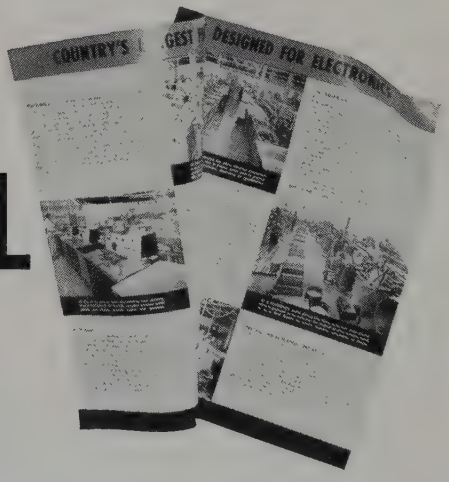
FREE TECHNICAL DATA



Precious Metal Plating of Electronic Components

A pictorial tour through the country's largest facility. Details electrochemical and mechanical procedures — from pilot plant "trial" runs to modern production techniques and quality control. Laboratory tests to meet tough military and commercial specifications. Also describes **free** prototype and sample plating service. Send for your free copy today.

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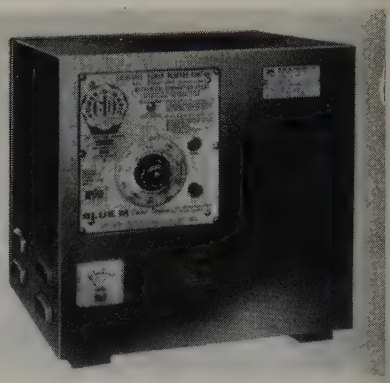
THE COUNTRY'S LARGEST PLATING FACILITY DESIGNED FOR ELECTRONICS

Circle No. 32 on Reader Service Card

Saturable Reactor Control Package



As a self-contained, convenient package, Blue M Electric Power-O-Matic 60 Saturable Reactor operates without contacts, switches, moving parts, potentiometer sliders, photo cells, etc. May be combined with products-in-design or used as a conversion kit for equipment with conventional on-off cycling control systems. Available as a complete reactor controller. Three ranges: −20°F to 650°F. Sizes: 2 K.V.A. to 10 K.V.A.

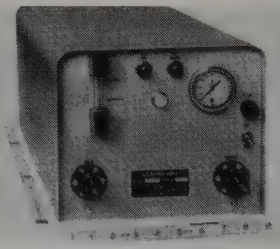
Circle 101 on Reader Service Card

Solid-State Crystal Puller

A new laboratory model of the Czochralski-type Crystal Puller is now available from Allen-Jones, Inc. This instrument was designed by Hughes Aircraft Company Semiconductor Research Laboratories to meet the requirements of the solid-state research and development engineer or scientist for the growing and pulling of elemental and compound semiconductor materials. An economical and versatile device, this instrument offers convenient operation of all mechanical assemblies.

Circle 117 on Reader Service Card

Transistor Heat Sink and Cooling System



Less power transistor derating is possible with the availability of a new line of liquid-cooled Heat Sinks manufactured by Electro Impulse Laboratory, Inc. Rated at 0.025°C per watt, a 1000 watt sink, with a 1-square foot transistor mounting surface, provides a 100-times improvement over the same heat sink in air. Heat sink temperature, at 1000 watts, is not more than 25°C above ambient, and the rating of 0.025°C/watt is maintained up to 100% overload.

Circle 129 on Reader Service Card

Mesa Transistors

A complete line of new Dalmesa transistors for industrial communications was announced by Texas Instruments Incorporated. The 2N2188 series features ultra-high performance for the entire communications band from d-c to 100 mc. This new family of germanium alloy diffused mesa transistors is characterized by minimum BV_{CBO} and BV_{CES} for the 2N2188 and 2N2189 at 40 volts, 60 volts for the 2N2190 and 2N2191. Maximum power dissipation is 125-mw at 25°C ambient.

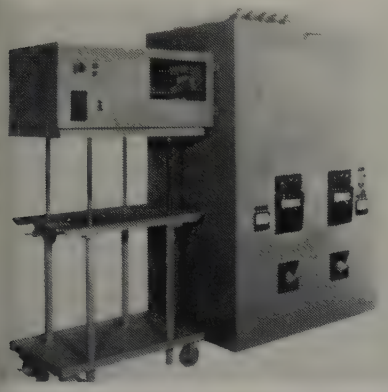
Circle 122 on Reader Service Card

Plastic Disposable Glove

An improved disposable glove made of "soft-formulation" polyethylene plastic has been developed and introduced by the Wilson Rubber Company. The new glove replaces the company's current P125 Poly-D glove in the Wil-Gard line, and is being sold under the same "Wil-Gard Poly-D" name. Its polyethylene formula gives the new glove extra toughness, touch sensitivity, and comfort. Heat bonded seams are strong and smooth, so that there is no irritation, and the plastic has more flexibility than standard polyethylene.

Circle 120 on Reader Service Card

Multi-Tube Furnace



Lindberg Engineering Company offers a four-tube diffusion furnace with a detachable automatic pusher mechanism. The furnace reaches a maximum temperature of 1300°C in its 36" long heating chamber, and has a rated uniformity of 18" plus or minus 1.0°C. It is operated by two zones of control. Dimensions of the furnace and base only are 37" wide, 75" high and 52" long. Addition of the pusher mechanism increases the length to 91".

Circle 103 on Reader Service Card

Germanium Power Transistors

Semi-Onics is now producing a line of p-n-p germanium power transistors in the TO-36 package. Some of the outstanding features of these transistors are: Low package height, 150 watt power dissipation, 0.5°C/watt thermal resistance and 100°C junction temperature. The electrical characteristics offer a beta range of 20-70 @ 5A I_c and a BV_{CBO} range of 40-100V. To insure high reliability, all transistors undergo a 48 hour, 115°C bake and a package leak test.

Circle 123 on Reader Service Card

Diode Clip

Teradyne, Inc. announces the Daymarc Diode Clip that automatically locates the test component in the contacts when it is dropped from the hand. Four contacts reliably permit error-free measurements. Ease of loading permits extremely high testing rates. Diodes and components with magnetic leads including glass resistors, capacitors, etc., rapidly handled even with bent leads.

Circle 126 on Reader Service Card

Design Sophistication

The TACT System, a product of Texas Instruments creative engineering, is a dramatically new concept in component test equipment design. The Transistor And Component Tester emphasizes digital control of analog functions, reducing analog circuitry to a minimum, and features absolute repeatability—never before achieved in component testing. TACT represents just one of many areas of developmental endeavor in growth-oriented Texas Instruments.

NEEDED NOW . . . senior level engineers experienced in the design and development of electronic test equipment. BS/MS degree in EE or Physics required plus five or more years' experience in electronic component test systems, commercial test instruments or high speed switching and pulse circuitry.

Send résumé to John Pinkston, Dept. B-2
Texas Instruments Incorporated
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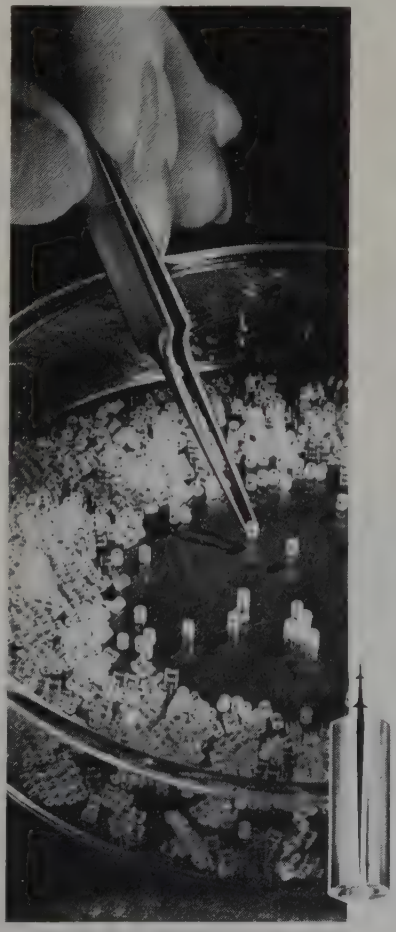
Circle No. 33 on Reader Service Card



Got a glass problem? T.H. GARNER COMPANY IS DIFFERENT

We machine-draw tubing to your new dimensions and ship in a matter of hours.

If your problem can be resolved by new dimensions (O.D., I.D., length) or tolerances, call us today for service.

Our own glass tube drawing facilities running 24 hours a day give us the flexibility to handle a variety of changes quickly.

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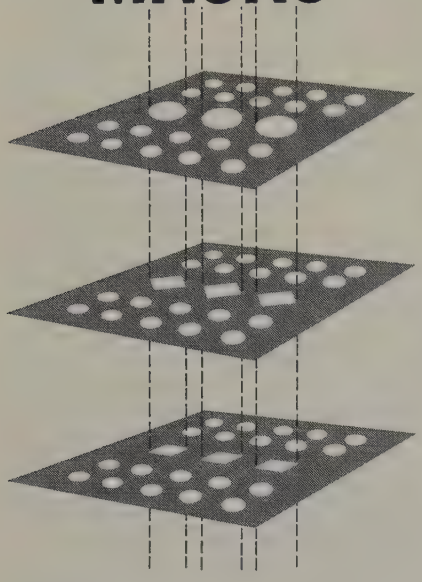
Serving the electronic and instrumentation fields since 1953

Circle No. 34 on Reader Service Card

TRI-LAB
TRANSISTOR MASKS



Tight Tolerance and Precise Positioning Mean Greater Yield

Why put up with low yield in transistor manufacturing? Why limit your design capability because of excessive tolerance in transistor masks? Tri-Lab holds center-to-center tolerance across the face of its masks to ±.0001 inch or tighter, depending upon the basic mask material. Matching tolerance of superimposing images is equally tight — Tri-Lab methods also allow you to design alignment configurations into your masks. The result — greater yield of better quality transistors. Now, with Tri-Lab you can also design semiconductor devices using metal masks with ½ mil spacing between image segments on 2 mil base material.

Equally important—Tri-Lab delivers the goods on time. Write for information on how you can profit from Tri-Lab capabilities.

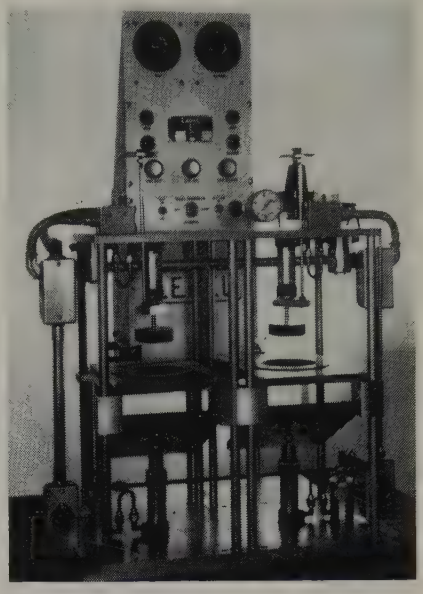
TRI-LAB ELECTRONICS, INC.
4319 Twain Avenue, San Diego 20, California

Tri-Lab offers new dimensions in subminiaturization through photography, electro-etching and metal deposition . . . transistor masks, matrices for character writing tubes, masks for microminiature circuitry, etched encoder disks for computers, selective etching of refractory metals, and electro-forming of intricate configurations.

Circle No. 35 on Reader Service Card

Induction Heating Fixture

Lepel High Frequency Laboratories, Inc., has designed and constructed a two-station induction heating fixture for brazing, shrink fitting, hardening and other heat treating operations. This versatile fixture allows the generator to operate at



maximum duty while permitting a minimum of work handling by the operator. After the loading is completed at one station, the operator depresses a foot-switch activating the control center which automatically takes over the functions of: transferring the high frequency power to the work station requiring heat; timing the heating cycle; timing the holding period for applied pressure or cooling; releasing the completed part. While one station is being automatically operated, the other station is loaded and the control center signalled. Heating will begin at the newly loaded station as soon as the heating action of the work cycle at the first station is completed.

Circle 110 on Reader Service Card

Diode Curve Tracers

Instrument Techniques makes available two reverse dynamic curve tracers for high-voltage diode testing. Both test sets provide 0 to 5 kv range at 60 cps in two steps with continuous verniers. Reverse current range is 20 microamps f.s. to 1 ma f.s. Model 1031-2A features true peak metering for current and voltage, plus oscilloscope plotting. Model 1031-2B provides a calibrated oscilloscope plot.

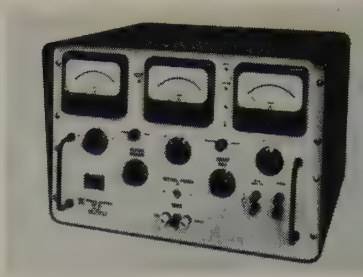
Circle 125 on Reader Service Card

Header With Tapered Side

A new header design, developed by Epoxy Products Division, Joseph Waldman & Sons, has a 6° tapered edge to provide a tight fit between the header and the case. The tapered fit prevents liquid encapsulant from leaking out of the case. The header fits standard 9-pin tube sockets and can be used for mounting plug-in modules, semiconductor networks, logic networks and memory cores. Outside diameter of the header is .700 inches. Outside diameter of a complete header and case module is .750 inches.

Circle 106 on Reader Service Card

Thermal Resistance Tester



A new thermal resistance tester has been announced by Wallson Associates, Inc. Model 222 is designed to accurately measure the junction temperature of semiconductor diodes and rectifiers. Front panel controls include heating current and null adjustments, ac-dc heating power switch and meters for reading current, voltage and degrees centigrade. Switching circuits permit heating currents up to 10 amperes, forward voltage drops to 5 volts and temperature to 150°C. The unit measures 13" x 19" x 15". An Adapter to permit thermal resistance measurements of transistors will be made available shortly.

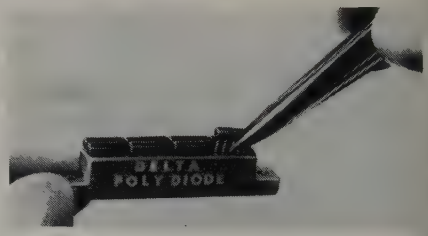
Circle 100 on Reader Service Card

Impregnated Nylon Glove

An especially impregnated glove for electronic component assembly has been added to the line of industrial work gloves manufactured by the Standard Glove Company. This new work glove is made from 100% nylon including the threads, is therefore completely lint-free, making possible the handling of critical components without contamination by lint, skin oils, fingerprints and other hand carried soils.

Circle 128 on Reader Service Card

Plug-In Poly-Diode



The Delta Poly-Diode provides a practical application to computer logic microcircuitry. The unit consists of up to five separate diode junctions, each with an individual lead, formed on a single silicon slice in a computer gate configuration. The entire circuit is glass encapsulated in a package about the same size as an ordinary single diode. Each micro plug with eight quad Poly-Diodes contains 32 diode junctions and measures .160" by 1.5". A typical installation has 32 micro plugs in a matrix measuring 2¾" by 3¼" containing a total of 1024 diodes.

Circle 135 on Reader Service Card

Electronic Micrometer

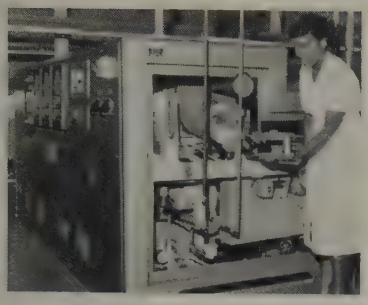
With the new Model HDR Carson-Dice Electronic Micrometer, measurements are displayed on a four digit counter reading to 20 millionths of an inch. Unskilled operators can make measurements with laboratory accuracy and precision. An optional foot switch which plugs into a socket on the rear of the base can be used instead of the lever switch to leave both hands entirely free for handling work. Instrument operates on 115 volts a-c.

Circle 105 on Reader Service Card

HERB WESTEREN, Asst. Dir. of R & D tells about another Hayes first —

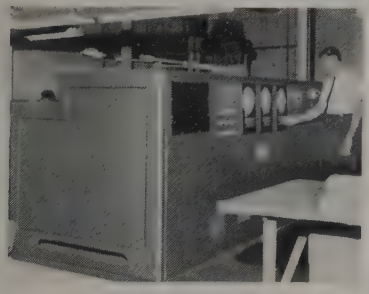
CONTINUOUS CONVEYORIZED VACU-MASTER®

(Pat. Applied for)



For the first time, vacuum processing has been put on a fully automated continuous basis — with C. I. Hayes Model VAC-50C Vacuum Conveyor Furnace.

Here's the *big* step toward error-free operation and scrap-free output! Operators at General Instrument Corporation of Newark, N. J. where this furnace is alloying diodes simply load "boats" into the vacuum-lock inlet. Work conveyance through the heat zone (1000°C ± 1°C max.) and return to atmosphere are all automatic, split-second functions: output runs as high as 80,000 diodes per 8 hr. shift. Yields and quality? Unsurpassed!



May we tell you more about this development — another Hayes breakthrough in vacuum heat treating? Write for Data Sheet FJE-1. C. I. Hayes, Inc., 847 Wellington Ave., Cranston 10, R. I.

C. I. HAYES, INC.

Established 1905

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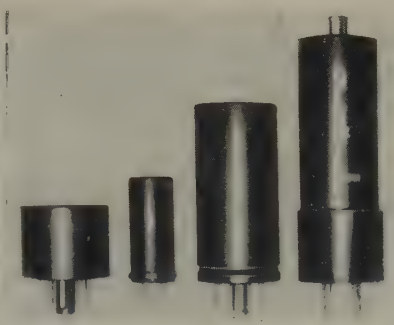
Silicon Rectifier Tube Replacements



General Instrument Semiconductor Division announces a new line of high voltage silicon rectifier replacement types (1N1237 series, 1N2630 series, 1N570, 1N1150, 1N2389, 1N2490) covering 1500 PIV to 10,400 PIV. Designed with standard tube bases (Octal, 4-pin, 5-pin, and 7-pin) for the direct replacement of mercury and vacuum tubes. All types have all-welded component connections in shatter-proof cases with ultra high dielectric strength and are highly resistant to extreme moisture, shock, vibration and acceleration.

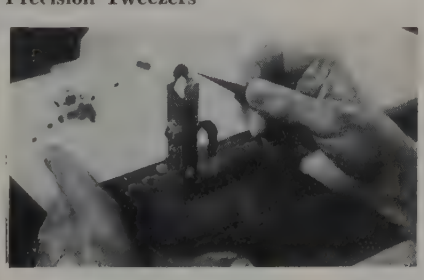
Circle 108 on Reader Service Card

Automatic Dice Sorter

The new TK-500 Auto-Sorter from Techni-Rite Electronics, Inc., offers a basic new design approach which overcomes the difficulty of feeding the tiny dice automatically, and thus completely eliminates all manual operations. The Auto-Sorter can gage and sort 2400 to 3200 dice per hour, to an accuracy of .000040", into 10 categories ranging in sizes from .000050" to .0002", including "Rejects" and "Reinspects." Various automatic controls, counters and shut-offs are standard equipment for maximum flexibility and convenience.

Circle 124 on Reader Service Card

Precision Tweezers



Hunter Tools has available over 75 different varieties of 'EREM' tweezers. A complete range of 'Dumont' and 'Boley' styles, as well as many EREM originals, are available to solve any electronic assembly problems that might arise. Most models are available in regular carbon steel, stainless, and a special 'EREMITE' Anti-Acid and Anti-Magnetic Stainless. A few special models are available in nickel, silver, and brass.

Circle 112 on Reader Service Card

Get Optimum

- thermal conductivity
- electrical conductivity
- sealing ability
- expansion compatibility
- processing qualities

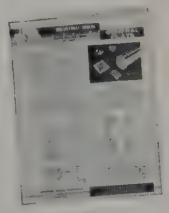
in one

MULtiLAYER* clad wire

#446 STAINLESS CLAD COPPER GLASS SEALING WIRE

Through the material matching magic of MULtiLAYER clad metals you can now have a glass sealing wire which has a copper core for conductivity and a stainless steel jacket for thermal expansion properties approximating that of glass. This means a perfect combination for glass-to-metal seal material for terminals, hermetic seal headers, switches, relays, coils, capacitors, rectifiers, transformers, potentiometers, etc.

The clad bond between the oxygen free high conductivity copper and the #446 stainless steel is an absolutely sound, metallurgical bond with no interliner, solder, or brazing alloy — continuous, complete, and gas tight.



WRITE or call Marketing Manager, Clad Wire department for FREE LITERATURE which gives physical and mechanical properties of this wire and other specifications such as co-efficients of expansion, temper, forms and sizes, and weights.

METALS & CONTROLS INC.,
2011 Forest Street, Attleboro, Mass.

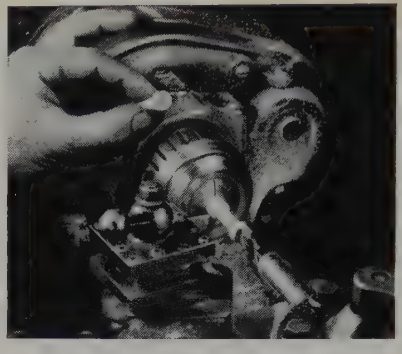
A CORPORATE DIVISION OF

TEXAS INSTRUMENTS INCORPORATED

Circle No. 37 on Reader Service Card

Problem: "On spec" yield of semi-conductor components drop as much as 40% within 50 cycles when using *graphite* jigs

Solution: **BORON NITRIDE**
for semi-conductor jigs



Boron nitride machines easily to close tolerances, resists chipping and retains internal jig details. It holds dimensions, has excellent release characteristics and is non-toxic.

Contact with silicon, germanium, indium, antimony, lead and other metals has little effect up to 1800 F in oxidizing or reducing atmospheres. For more information on greater yields with boron nitride, write Latrobe Plant, Refractories Div., Carborundum Co., Latrobe, Pa.

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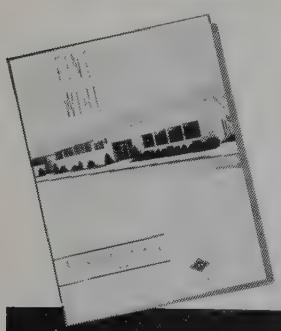
FINE WIRE

for
- Semiconductors
- Resistors
- Potentiometers
- Thermocouples
- Electronic Tubes
- Other Electronic Applications

in
precious, base, exotic and special metals — bare or insulated

Custom Melting, Complete Redrawing, Strand and Vacuum Annealing Services for fine wire processing to customers' specifications.



WRITE for valuable brochure containing fine wire compositions, pertinent properties and applications.

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CONSOLIDATED REACTIVE METALS, inc.
115 Hoyt Avenue — Mamaroneck, N.Y. — OWens 8-2300

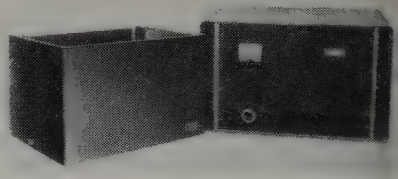
Circle No. 39 on Reader Service Card

Semiconductor Manufacturing Materia

Diotran Pacific announces a new lir of high quality tungsten carbide lea bond wedges, diamond scribers an diamond lapping points. The TC lea bond wedges provide positive bonding fine gold conductive wire, to 0.0005", semiconductor material. Diamond scriber designed for precision dicing of silico wafers, are available in two basic types single point and "quad" point. The dia mond lapping points are designed for us with standard lapping machines. Th stone is precision ground and machin polished to a radius of approximatel 0.090".

Circle 136 on Reader Service Card

Ultrasonic Generator



Ultrasonic Systems, Inc., announced new, high-energy ultrasonic generator Model UG 1000. Output is 1000 watts aver age. Used with the 11-gallon tank, Mode UT 110, also supplied by USI, the gener ator drives high efficiency lead Zirconat Composite transducers, providing power-to-capacity ratio of 91 watts pe gallon. Other features include drift-fre master oscillator, and power amplifier cir cuit permitting full output on 1-volt in put.

Circle 121 on Reader Service Card

Applications

(*from page 33*)

load. In the case of inverters, a load using the entire supply voltage, be sure there is some load on the output. Under non-load conditions the induced voltage spikes, which appear collector-to-emitter on each transistor, can be extremely high and might cause permanent damage. In the case of the converter, the diodes and filter condensers on the output will provide sufficient must be added. Usually, several thousand ohms is sufficient.

By viewing the collector-to-collector wave form, *Fig. 75.4*, the operating frequency can be calculated, and the amplitude (C) can be checked to insure that it is equal on each half of the cycle and approximately equal to $2E_c$.

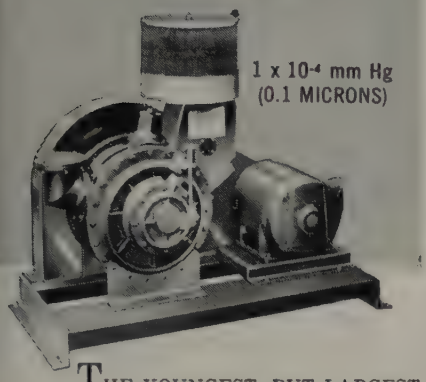
This circuit has short-circuit protection—if the output is shorted, the drive power available to the transistors is insufficient to support the load, therefore the loop gain becomes less than unity.

Circle 200 on Reader Service Card

NEW! HIGH CAPACITY!

TWO-STAGE WELCH "DUO-SEAL" VACUUM PUMP No. 1398

50 CFM (1400 LITERS/MINUTE)



1 x 10⁻⁴ mm Hg (0.1 MICRONS)

THE YOUNGEST, BUT LARGEST MEMBER of the Welch family of "Duo-Seal" oil sealed rotary vacuum pumps makes its appearance as the No. 1398. This new pump offers very high capacity and excellent ultimate vacuum characteristics with no sacrifice of long life, low maintenance, freedom from vibration and minimum noise level. These features have long made Welch "Duo-Seal" pumps the most widely used of all rotary vacuum pumps.

1398's, like all Welch "Duo-Seal" Pumps, are thoroughly run-in at the factory and tested until they exceed their vacuum guarantee.

The new 1398 is highly recommended for all industrial and laboratory applications requiring high pumping capacities and low pressures. Typical uses are electron tube evacuation, vacuum distillation, dehydration, reduction, sublimation, metallizing, metal processing, leak detection, hermetic sealing and back-filling, impregnation and general scientific studies.

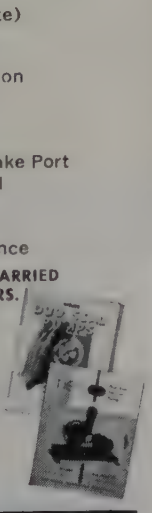
IMPORTANT FEATURES:

- High pumping speed — 50 CFM (1400 liters/minute)
- Low ultimate pressure — 1 x 10⁻⁴ mm Hg (McLeod)
- Quiet, vibration-free operation
- Compact, rugged design
- Air-cooled
- Vented Exhaust Valve
- Flanged, O-Ring-Sealed Intake Port
- Totally Enclosed Belt Guard
- Air Intake Screen
- Exhaust Filter
- Trouble-free, low maintenance

WELCH "DUO-SEAL" PUMPS ARE CARRIED IN STOCK BY AUTHORIZED DEALERS.

Welch Duo-Seal Vacuum Pumps are manufactured in wide variety of capacities and ultimate vacuum characteristics. They range in capacities from 21 to 1400 liters/minute and ultimates from 2 x 10⁻² mm Hg down to 1 x 10⁻⁴ mm Hg.

WRITE FOR DUO-SEAL CATALOG and BULLETIN 1398 for full description and prices.



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Circle No. 40 on Reader Service Card

Personnel Notes

Three key research appointments for Allied Chemical's General Chemical Division have been announced by John C Fedoruk, technical director. William C Ruch has been named director of development research; Dr. Robert W. Mason, director of laboratory research, and Charles D. Boyer, Jr., director of planning research Their headquarters is at the General Chemical Research Laboratory in Morris Township, New Jersey.

Arthur Snyder, Jr., has been appointed Controller of the Behr-Manning Division of Norton Company. In this capacity, he will be the chief financial officer of the company's coated abrasives and pressure sensitive tape manufacturing division at Troy, New York.

Richard J. Newman has been promoted to the newly-created position of Director of Planning and Development for The Daven Company, a member of the General Mills Electronics Group, Livingston, New Jersey, it was announced by Mr. Kenneth J. Carlson, General Manager. Mr. Newman will be responsible for the planning and development of new product lines.

Robert E. Hysell has been appointed manager of materials engineering for the General Electric Company's Rectifier Components Department, Auburn, N. Y. The announcement was made by R. A. York, manager of engineering for the Department, who said Mr. Hysell will be responsible for semiconductor crystal growth, pellet fabrication and evaluation. His most recent assignment was manager of measurement studies at the Advanced Semiconductor Laboratory, Syracuse, N. Y

Charles Saso has been elected President of Duramic Products, Inc., 426 Commercial Avenue, Palisades Park, N.J. Mr. Saso, who has been with the firm since it was organized in 1955, was Vice-President and General Plant Manager prior to his elevation to the presidency. He succeeds Herbert Schwartz, who left the company in July. Alfred Gordon has been named Sales Manager. Duramic is a subsidiary of Accurate Specialties Co., Inc. of Hackensack.

A division of Alloys Unlimited, Inc., Electronics Glass and Ceramics Corp., manufacturers of beaded leads and glass seals, announced the appointment of David Baldwin as production manager of the company's plant at Cambridge, Mass. For the past six years Mr. Baldwin was employed in a similar capacity by the components division of Sagerstown Glass Seals, Inc.

Dr. S. Roy Morrison, senior staff scientist at the Minneapolis-Honeywell Research Center in Hopkins, Minn, has been promoted to assistant director of the center. He succeeds Dr. John R. Dempsey, who recently was named director of the center to fill the vacancy created by the resignation of Dr. Finn Larsen, now assistant secretary of the Army in charge of research and development.

SEMICONDUCTOR OPPORTUNITIES

$12,000 to $25,000

MANAGER, DEVICE DEVELOPMENT LABORATORY

Medium sized manufacturer of semiconductor devices seeks Ph.D. with 5 or more years experience in Research and Development including at least two years in management capacity. Will have complete charge of directing, hiring and training engineers and scientists in advanced device development. Very attractive opportunity with many fringe benefits. Salary to $25,000.

PRODUCT ENGINEERS

Major electronics firm has several openings in their semiconductor division for men with 3 or more years experience in product, process and sustaining engineering. Men will take devices from advanced development group, determine processes available, set up pilot line, improve devices as necessary and scale up for production. Will act as consultant to production group to maintain highest possible yield. Men will definitely have to know all concepts of the devices and processes. Salaries to $16,000.

ADVANCED MEASUREMENTS MANAGER

Major electronics manufacturer expanding present semiconductor division seeks man with advanced degree, and several years experience designing test instrumentation, to head up group doing advanced measurements on UHF devices with potential of measuring at .05 nanoseconds. Will be responsible for hiring, training and directing other engineers and scientists. Salary to $22,000.

MICROCIRCUITRY ENGINEERS

Expanding semiconductor manufacturer seeks several men with experience on thin film sputtered tantalum to do applied research and device development on resistors and capacitors. Men will work with a group of scientists doing advanced research in all phases of microelectronics and have excellent equipment and facilities at their disposal. Salaries to $18,000.

PHYSICAL METALLURGIST

The semiconductor division of a leading electronics firm seeks a Ph.D. in Physical Metallurgy who is familiar with joining and metal forming of non ferrous metals. Man will definitely need experience in ceramics, germanium, silicon, II-IV and III-V compounds. Salary to $18,000.

APPLICATIONS ENGINEERS

Rapidly expanding semiconductor manufacturer seeks several men for the Application Department with knowledge of device design. Most work will be in digital circuitry, from low frequency to UHF, with emphasis on non-saturated AC amplifiers. Salaries to $14,400.

RELIABILITY SCIENTIST

Advanced semiconductor group seeks top Ph.D. in solid state physics to head up reliability group to predict and determine failure analysis on semiconductor devices and advanced microelectronics. Salary to $22,000.

MATERIALS MANAGER

Major semiconductor manufacturer seeks Ph.D. in Physical Chemistry with heavy experience in epitaxial growth of single crystal germanium and silicon. Man should be device oriented and capable of directing other engineers and scientists. Salary to $18,000 + Stock Option.

SCORES MORE

All expenses paid by employers. Completely confidential—no referrals without your permission.

If you are interested in knowing more about these and many other Semiconductor Executive position available through our services but don't have a prepared resume, simply jot your home address and phone number on the back of your business card and mail it to:

Glenn J. McKorkle
Mgr., Semiconductor Division

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WEbster 9-3833

serving the electronics industry exclusively—with integrity

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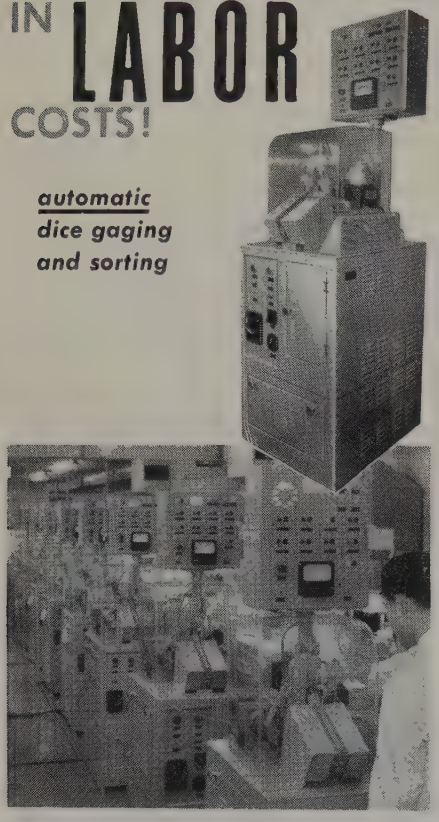
80% SAVINGS IN LABOR COSTS!

automatic dice gaging and sorting



TK-500 AUTO-SORTER

You can eliminate completely up to 4 out of 5 of your dice/wafer inspection and sorting personnel with the Auto-Sorter! This precision, high speed production unit automatically gages and sorts germanium or silicon dice into various categories . . . faster and far more accurately than human hands.

Over 200 TK-500 Auto-Sorters are now in constant service. Let a Techni-Rite sales engineer show you how this experience can cut your dice sorting costs, too.

Phone, Wire or Write for Illustrated Folder

techni-rite ELECTRONICS, INC.

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REgent 7-2000 TWX WRWK 266

Circle No. 42 on Reader Service Card

New Literature

An eight page catalog entitled "Tweezers and Lightweight Pliers for Precision Industries" illustrates and gives the applications of these watchmakers' tools. Hammel, Ringlander & Co., Inc.

Circle 170 on Reader Service Card

New bulletins describing in detail the features and capabilities of two zone scanners are offered by Lindberg Engineering. Bulletin 1530 illustrates and describes a Horizontal Zone Refining Scanner (Model LA-HSE 3612ZR). Bulletin 1531 details and illustrates Vertical Floating Zone Scanner (Model LA VSE 24ZR).

Circle 171 on Reader Service Card

Lafayette Radio Electronics Corp., announces its new 1962 catalog, with the latest in electronics equipment. The #620 catalog contains 340 pages and is the largest and most comprehensive ever offered by the company. Items include everything in science and technology for hobbyists, students, experimenters and industry.

Circle 172 on Reader Service Card

Available from Blue M Electric Company is their new illustrative two-color, 4 page Bulletin No. 1961 entitled Power-O-Matic 60 Saturable Reactor Industrial Batch Ovens. Bulletin also contains complete specifications on Power-O-Matic 60 Batch Type Ovens, Power-O-Matic 60 Five Drawer Ovens, Economy Industrial Batch Ovens and Economy Stabil-Therm Batch Type Ovens.

Circle 173 on Reader Service Card

Described in an 11-page brochure are custom-made metal-bonded ceramic-metal assemblies and metal-bonded ceramics. Made to exacting tolerances, they are used as hermetic seals in equipment such as transformers, relays and capacitors that are required for rugged service conditions including high altitude and space applications. The Carborundum Company, Refractories Division.

Circle 174 on Reader Service Card

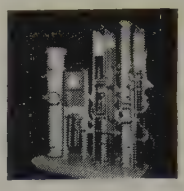
Newark Electronics Corporation has announced the publication of their new 1962 Catalog No. 72. It contains 500 pages of the latest releases from more than 500 manufacturers. For the user's convenience, the catalog features grouping of components for easy reference. More than 70,000 items are listed.

Circle 175 on Reader Service Card

Handbook Preferred Circuits, Supplement No. 4, NAVWEPS 16-1-519, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 48 pages, 35¢. Supplement adds four new transistor circuits to the Handbook. Copies of the Handbook and the first three supplements are still available from the Superintendent of Documents.

Circle 180 on Reader Service Card

Demineralizing Equipment NEWS from Penfield



Fully "Packaged" System Supplies 125-150 GPH of 18 Megohm Water

Penfield's new S-150 Demineralizing System includes multiple influent filters to remove turbidity, master dual-column demineralizer, scavenging carbon filter, polishing mono-column demineralizer, sub-micron effluent filter — all completely "packaged" on a single skid, ready to deliver an effluent of 18 megohms and better upon simple connection to service lines. (Other fully "packaged" Penfield systems available with capacities from 60 to 10,000 GPH.)

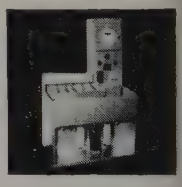
Pressure-Type Demineralizer "Polishes" to Ultra-High Purity at Point-of-Use

The Penfield PM-8 Demineralizer supplies up to 50 GPH of 18-22 megohm water — is ideal for point-of-use "polishing." Permanent cartridge design prevents raw water by-pass experienced with "canned" resin units. Cartridge unscrews by hand to permit easy resin renewal from bulk supplies, enabling substantial savings in replacement resin costs. Unit also can be charged for use as a cation exchanger, anion exchanger, carbon filter, oxygen or organic remover, and is adaptable for scavenging oil from gases.

In-Plant Regeneration Unit Saves 90% of Costs of Demineralized Water

A Penfield Regeneration Unit makes the renewal of exhausted resins from Point-of-Use Demineralizers an easy in-plant function. Operator merely feeds resin into unit, then turns a single master switch to control resin separation, regeneration, rinsing and proper re-mixing. Average operating cost, including all labor and regenerants, is less than 30c per cartridge.

Fully Integrated Weir Washer "Polishes," Heats, Monitors, Cascading Water



Integral filters and pressure-type demineralizers enable circulation of 18-22 megohm water through multiple partitioned tank of a special weir design that precludes stagnation. Direct reading conductivity meter permits instant monitoring at any of three check points. Novel clip bar makes replacing heat elements simple. (Penfield also constructs weir washer tanks in standard sizes or to customer specifications, using a wide variety of materials such as block tin, cast acrylic plastic, etc.)

15 years of ion exchange pioneering means that Penfield has on file field-proved answers to most industrial water problems — usually can detail the system you need by phone, ship your completely "packaged" units in a matter of days. Try a phone call or letter and see for yourself.

Penfield Manufacturing Co., Inc.
Telephone: BEverly 5-1694
19C High School Ave., Meriden, Conn.

Serving the Electronics Industry with Ion Exchange Systems • Filters • Weir Washers • Parts Baskets

Circle No. 43 on Reader Service Card

DICING

Know the odds against throwing a 7 with any one cast of the dice? There are 6 combinations that will produce a 7 and 30 that will not, so the odds are 5 to 1. Not bad for a game of dice, but pretty risky when it comes to dicing. But dicing is no gamble at Semiconductor Specialties. Gang saw and ultrasonic dicing, that is. We eliminate the gaming aspect by loading the dice in your favor . . . by combining a thoroughly experienced staff, the proper equipment, and processing ingenuity. To throw 7 every time you need precision processing, find out about the only complete semiconductor materials processing service . . . now available at Semicondutor Specialties. Seven, come eleven!

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PRescott 3-6933

Circle No. 44 on Reader Service Card

The Semiconductor Division of General Instrument Corporation has released a new bulletin, CC-1, covering the company's full line of encapsulated circuit modules designed to meet any specific applications in military and industrial electronics, as well as special products fields. Included in the bulletin are technical data, circuit designs, dimensional diagrams, and coding schemes. Also included is a separate specification sheet which can be filled out by engineers and returned to the company for study of components best suited for specific applications, a design for the required circuitry and a preliminary estimate.

Circle 176 on Reader Service Card

A new line of high temperature metalized ceramic terminals and feed throughs, manufactured by Metalizing Industries, Inc., is discussed in the company's recently published Bulletin M-104. The two-page technical sheet uses text, photographs and detailed drawings to describe the components. Bulletin also lists several performance properties.

Circle 177 on Reader Service Card

A new brouchure which describes the manufacture of high quality transistors, diodes, and other semiconductor devices has been made available by Sylvania Electric Products Inc. The 12-page illustrated booklet lists major steps in the design and manufacture of semiconductor products, and explains the role of research and testing in assuring long-life, reliable components.

Circle 178 on Reader Service Card

A specially prepared two-color, four page folder featuring the KPT/KSP Series Cannon Plugs available under the new 'Caps' program, has been prepared by Schweber Electronics. The fully illustrated folder contains all pertinent information, in quick-reference, tabular form, to aid buyers and engineers in the selection of these plugs.

Circle 179 on Reader Service Card

Wakefield Engineering Inc., 12-page Handbook thoroughly covers Semiconductor Cooling in theory and practice. Explains temperature, power, and airflow measurement techniques and rating procedures.

Circle 159 on Reader Service Card

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1.00 Each

1958—Jan/Feb; March/April; May/June; Nov/Dec.

1959—Dec.

1960—March, May, June, July, Aug., Sept., Nov.

1961—Feb., Mar., April, May, June, July, Aug., Sept.

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at HARVEY RADIO

DELCO RADIO SEMICONDUCTORS are on the move!

• NEW TYPES
• NEW PRICES

HIGH POWER TRANSISTORS

TYPE	PACKAGE	PRICE	
	50 AMP. ROUND BASE		
		1-99	100-999
2N1522	TO 36	$18.25	$13.50
2N1523	TO 36	24.30	18.00
	35 AMP. ROUND BASE		
2N1520	TO 36	10.45	7.75
2N1521	TO 36	11.80	10.25
	25 AMP. ROUND BASE		
2N1518	TO 36	7.05	5.25
2N1519	TO 36	10.80	8.00
	15 AMP. ROUND BASE		
2N1100	TO 36	16.20	12.00
2N1412	TO 36	12.85	9.50
2N1970	TO 36	5.70	4.25
2N1099	TO 36	9.45	7.00
JAN 2N174	TO 36	14.85	11.00
2N1358	TO 36	14.85	11.00
2N1358 (Sig. C)	TO 36	14.85	11.00
2N174A	TO 36	14.85	11.00
2N174	TO 36	6.40	4.75
2N173	TO 36	5.70	4.25
2N443	TO 36	5.40	4.00
2N278	TO 36	4.75	3.50
2N442	TO 36	4.35	3.25
2N277	TO 36	3.40	2.50
2N441	TO 36	3.00	2.25
	5-7 AMP. DIAMOND BASE		
2N392	TO 3	4.05	3.00
2N1011	TO 3	4.75	3.50
2N1011 (Sig. C)	TO 3	9.50	7.00
2N1159	TO 3	4.75	3.50
2N1168	TO 3	2.70	2.00
2N1534	TO 3	2.05	1.50
2N1535	TO 3	2.10	1.60
2N1536	TO 3	3.45	2.55
2N456A	TO 3	2.35	1.75
2N457A	TO 3	2.95	2.20
2N458A	TO 3	4.20	3.15
2N1021	TO 3	5.70	4.25
2N1022	TO 3	8.80	6.50
2N1160	TO 3	5.05	3.75
	3-4 AMP. DIAMOND BASE		
2N665	TO 3	$10.80	$8.00
2N665 (Sig. C)	TO 3	10.80	8.00
JAN 2N665	TO 3	10.80	8.00
2N669	TO 3	1.60	1.20
2N553	TO 3	5.40	4.00
2N1971	TO 3	4.05	3.00
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	1.5 AMP. MINIATURE DIAMOND		
2N1172	TO 37	3.10	2.30
2N1611	TO 37	3.70	2.75
2N1612	TO 37	4.75	3.50

POWER RECTIFIERS

TYPE	PACKAGE	PRICE	
	22 AMPERES		
1N1191A	DO 5	2.35	1.75
1N1192A	DO 5	3.00	2.25
1N1193A	DO 5	4.05	3.00
1N1194A	DO 5	5.40	4.00
	40 AMPERES		
1N1183A	DO 5	3.25	2.40
1N1184A	DO 5	3.90	2.90
1N1185A	DO 5	5.05	3.75
1N1186A	DO 5	6.75	5.00

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PRODUCTS OF GENERAL MOTORS CORP.

DISTRIBUTED BY . . .

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JU 2-6380

Circle No. 45 on Reader Service Card

Graphite Facts

by George T. Sermon, President
United Carbon Products Co.

Some small talk...

From my past comments in this column, some may suspect that I disapprove of small, local shops.

The truth is—*we both need them.* They serve United by keeping our plant free from the clutter of non-profitable, low volume orders. Also, they force us to keep on our toes when competing for jobs we both can handle profitably.

These same shops provide you with single graphite parts, customized for you, at a reasonable price. Delivery and service are good.

How we both serve you — each in our own way — is illustrated best by newspapers. In Bay City we like our local daily — *The Bay City Times.* But, with its plant and editorial staff, we know it couldn't handle the job of putting out the *New York Times.*

And, if the *New York Times* plant and staff had to be supported by Bay City, papers would cost a dollar or more apiece.

That's why it is wise for management in considering sources for vital graphite parts to review their own market potential.

United has the experience, staff, plant and financial strength to help you achieve a profitable volume. That's our objective.

UNITED carbon products co.

BOX 747 BAY CITY, MICHIGAN

Circle No. 46 on Reader Service Card

INDEX TO ADVERTISERS

For reference purposes, the advertisers index includes all regular advertisers who have run within the current contract year. These advertisers who appear in this issue are indicated by the page number adjacent to their listing, and are shown in a bold-face type.

Accurate Specialties Co. Inc. 12
Acoustica, General Ultrasonics Division 43
Advanced Vacuum Products, Inc.
Aerotronic Associates, Incorporated
Allied Chemical Corporation General Chemical Division Cover II
Alloys Unlimited Incorporated 6, 7
Alloys Unlimited Chemicals, Incorporated
Alpha Metals, Incorporated
American Optical Company
Art Wire & Stamping Company
Avnet Corporation

Baker, J. T. Chemical Company
Barber-Colman Company Wheelco Industrial Instruments Division
Becco Chemical Division Food & Machinery & Chemical Corporation 42
Bell Telephone Laboratories
Blue M Electric Company
Brady, W. H. Company
Bronwill Division of Will Corporation
Burke & James, Incorporated

Carborundum Company 50
Ceramics For Industry Corporation
Charleston Rubber Company
Chemclean Products Corporation 5
Classified 56
Cohn, Sigmund Corporation
Cominco Products, Inc. 45
Consolidated Reactive Metals, Incorporated 50
Crane Packing Company 3

Davies-Shea, Incorporated 51
Del Electronics Corporation 46
Delta Design, Incorporated
Design Tool Company
Despatch Ovens Company
DI-Tran Corporation
Dixon, Wm., Incorporated
Dow Corning Corporation 4
Duramic Products, Incorporated
Dynatron Electronics Corporation

Eagle-Picher Company, The 13
Eisler Engineering Company, Incorporated 54
Electro Impulse Laboratory
Electronic Metals and Alloys Inc. 14
Elinex
Engelhard Industries, Incorporated

(Continued on Page 55)

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Turn to section 2100

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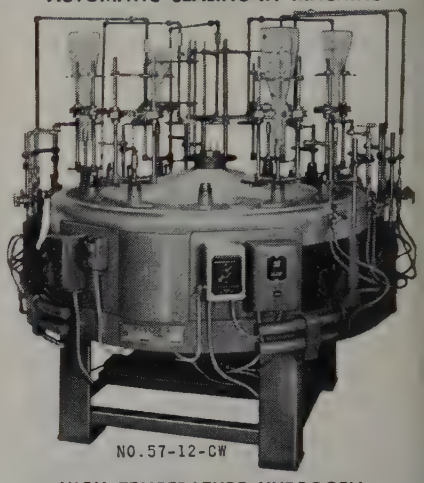
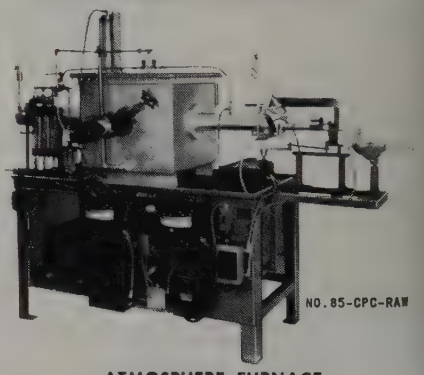
EISLER.... a name to remember in GLASS WORKING MACHINERY —Automatic and Semi-Automatic Machines to suit your production needs in the electronic and TV tube industry.

EISLER 7½ KVA PRECISION VERTICAL SPOT WELDER

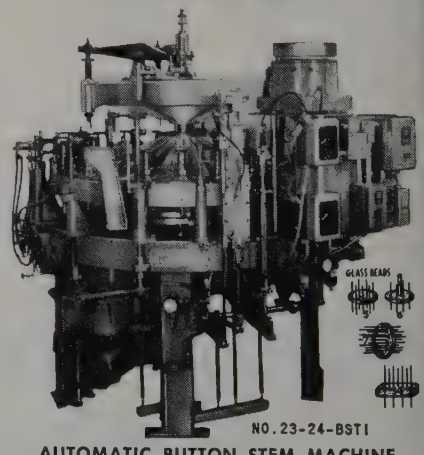
AUTOMATIC SEALING-IN MACHINE



HIGH TEMPERATURE HYDROGEN



ATMOSPHERE FURNACE

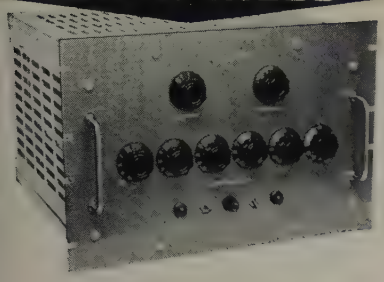


AUTOMATIC BUTTON STEM MACHINE

EISLER ENGINEERING CO., INC.
766 So. 13th St., Newark 3, N.J.

Circle No. 47 on Reader Service Card

NORTH HILLS'



Model CS-140

GYRO TORQUER SUPPLY

- Precision Current Source
- DC and/or AC
- Pulse Output Possible

For testing and measurement of gyro torquers, zener, reference diodes, magnetic components, other current sensitive devices.

- Current Range is 0.1 μa to 150 ma
- Regulation 0.002%
- Resolution 1 part per million

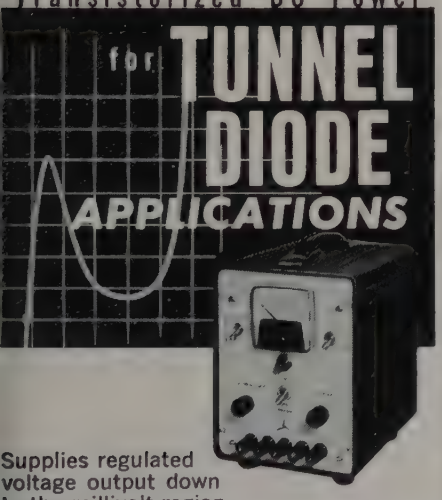
In use by leading companies for gyro torquer supply, component reliability testing, calibration, reference zener testing.

Literature describing this and other constant current sources from 0.1μa to 30 amp. may be obtained from

nh NORTH HILLS
ELECTRONICS, INCORPORATED
GLEN COVE, L.I., N.Y. | ORiole 1-5700

Circle No. 48 on Reader Service Card

Transistorized DC Power for TUNNEL DIODE APPLICATIONS



Supplies regulated voltage output down to the millivolt region for tunnel diode biasing applications. Switchable to a constant current supply. Settable short circuit protection also makes it an ideal unit for general laboratory use.

Model	Volts	Amps	Price
T20-2	0-20	0-2	$199.50
T50-750	0-50	0-¾	199.50
*T50-1.5	0-50	0-1.5	249.50

*Constant voltage only.

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Fisher Scientific Company

Garner, T. H. Company 47
General Electric Company
Lampglass Division
Semiconductor Products Department
General Instruments Corporation
Graphic Systems
Greibach Instruments Corporation

Harvey Radio Co., Inc. 53
Hayes, C. I. Incorporated 49
Hevi-Duty Electric Company
Hughes Aircraft & Company

Indium Corporation of America, The 40
Industrial Instruments, Incorporated

Jelrus Technical Products Corporation
Johnson & Hoffman Manufacturing Corporation 41

Kahle Engineering Company ... 18
Kanthal Corporation, The
Kennedy Company 41
Kewaunes Scientific Equipment
Kessler, Frank Company, Incorporated
Kulicke & Soffa Manufacturing Company, The

L & R Manufacturing Company
Lafayette Radio 56
Lepel High Frequency Laboratories 55
Lindberg Engineering Company 17

Mallinockrodt, Industrial Chemical Division
Mann, David W. Company A Division of Geophysics Corporation of America 44
Manufacturers Engineering & Equipment Corporation
Marshall Products Company
Merck & Co., Inc. Electronic Chemicals Division 1, 8
Micromech Manufacturing Corporation 16
Milgray ..... **Cover IIA-IIB**
Monsanto Chemical Company
Newark Electronics Corporation
New York Air Brake Company
The Kinney Manufacturing Division
North Hills Electronics, Incorporated 55
Norton Company 9

Ohio Carbon Company
Optimized Devices, Incorporated

Penfield Manufacturing Company, Incorporated 52
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(Continued on Page 56)

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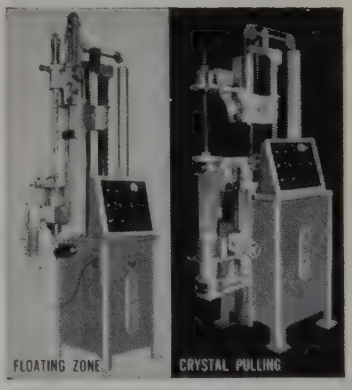

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Schweber Electronics
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Semi-Alloys Incorporated
Semiconductor Specialties Corporation 53
Semimentals, Inc. 20
Sprague Electric Company Cover IV
Sylvania Electric Products, Incorporated
Parts Division 11
Chemical & Metallurgical Division

Techni-Rite Electronics, Incorporated 52
Tech-Publishers 54, 55, 56
Tektronix, Incorporated
Temperature Engineering Corporation
Tempress Research Company, Inc. 15
Texas Instrument Incorporated
Apparatus Division 10, 47
Geosciences & Instrumentation Div.
Metals & Controls Div. 49
Semiconductor-Components Div.
Trak Electronics Company
Trans Electronics Corporation
Tri-Lab Electronics, Inc. 48
Tri-Metal Works, Incorporated
Trinity Equipment Corporation
Trygon Electronics, Incorporated 55

United Carbon Product Company 54
Unitron Instruments Division of United Scientific Company

Vactronic Lab. Equipment Inc. 43
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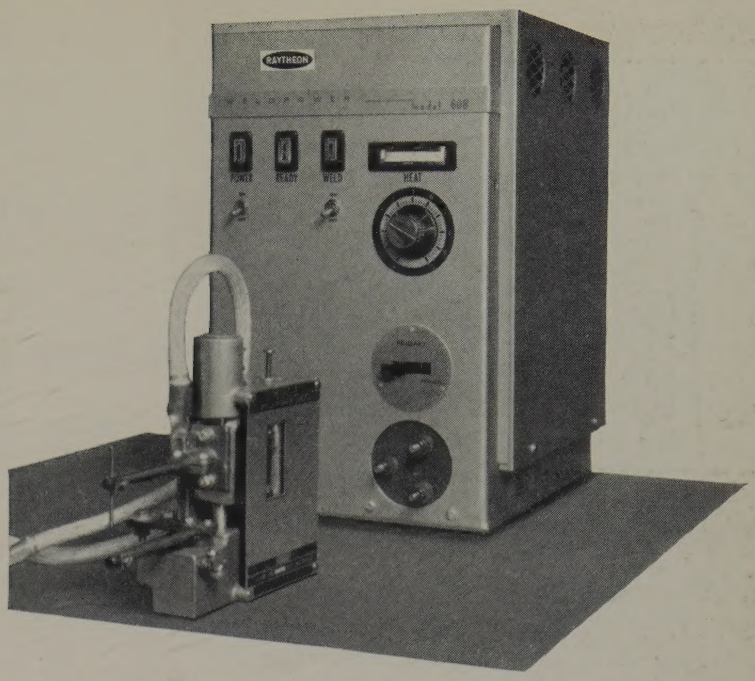

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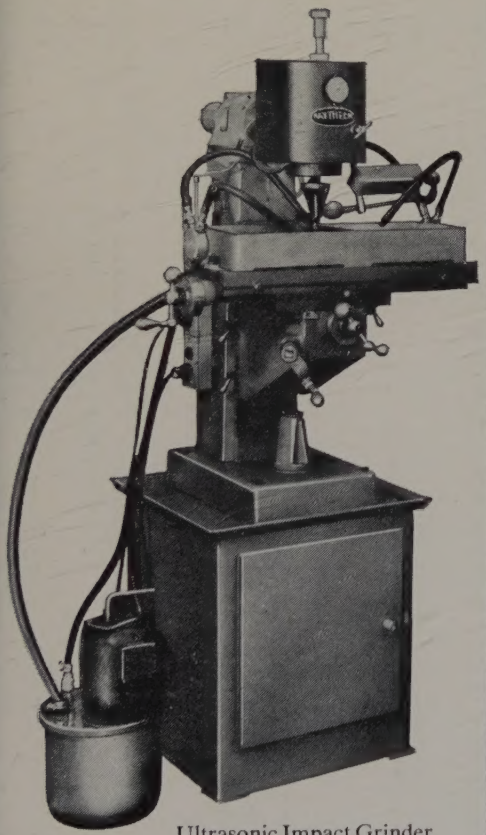

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f_T	100 mc min

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